DISCOVERY

HE PROGRESS OF SCIENCE

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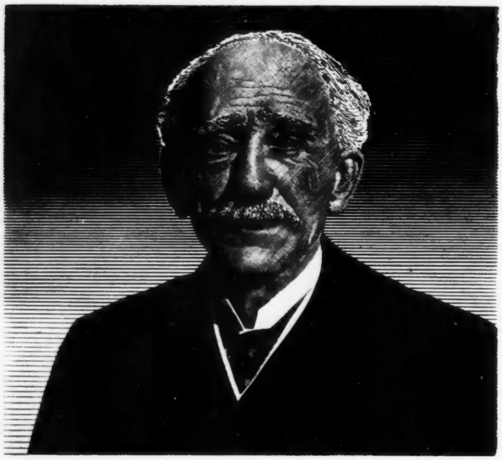
assistant checks the patient's perature and the electro-diograph record during an ration involving 'artificial ernation'. *See pp. 443–5.*

NOVEMBER 1954 **2/-**



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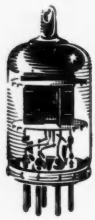

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THE PROGRESS OF SCIENCE

THE END OF THE OPPENHEIMER AFFAIR

The Oppenheimer affair has deeply shocked a great many people, and in a few minds it has already assumed the status of a *cause célèbre* in some respects reminiscent of the Dreyfus case—though that analogy seems to break down completely at the point when one begins to consider the chances of Oppenheimer's case being reopened; there seems to be practically no prospect of that happening—even the *Bulletin of the Atomic Scientists*, which has been wholehearted in its support of Oppenheimer throughout, concedes that the Oppenheimer matter "is a completed chapter" in the annals of American security.

Mountains of newsprint have been used up in discussion of the pros and cons of the case, and public interest in it has extended far beyond the shores of America. Immediately after the verdict of the special Personnel Security Board chaired by Mr. Gordon Gray—the Gray Board—was announced, the general reaction in Britain seemed to be that Oppenheimer had had a very raw deal. That reaction in Britain doubtless owed something to the inadequate way in which the Oppenheimer case was presented in the British daily papers. Today there is no longer any need for anyone in this country who wants to reach an informed opinion on this affair to remain in ignorance of the full facts that were put before the Gray Board. The complete transcript of the evidence is now available in book form from H.M. Stationery Office.* The transcript runs to 992 pages, and until one has read the whole of this volume along with the report of the Gray Board (summarised in DISCOVERY, July 1954, pp. 298–99) one is scarcely entitled to jump to conclusions about the Oppenheimer case. It is quite clear from the evidence that Oppenheimer had a very fair hearing. Whether the board of inquiry which reviewed that evidence delivered a sound judgment is, of course, an entirely different matter. There is no doubt that many American scientists disagree with that judgment; indeed the one scientist (Prof. Ward Evans) on the Gray Board disagreed with both his colleagues, and his conclusions about the case resemble those of Dr. H. D. Smyth, the scientific member of the A.E.C. (which had to review the Gray Board's recommendations) who disagreed with the other members of the commission and voted in favour of the restoration of Oppenheimer's security clearance.

What the transcript does make abundantly clear throughout is that all the members of the Gray Board, and nearly all the witnesses who appeared before it, regarded it as a matter for great regret that circumstances should have necessitated the investigation at this late date of the record of a scientist who, during the war, rendered signal service to his nation. There are elements of tragedy in the affair, and the odd touches of humour which are present in the transcript (there was, for instance, the scientific witness who evidently itched to fight a duel with another witness with whom he bitterly disagreed!) only serve to heighten by counterpoint the inner tragedy of the whole sad, sorry business.

The evidence also makes clear just how influential Oppenheimer had been in high policy-forming circles. Much of his influence depended upon the fact that he was chairman of the General Advisory Committee of the A.E.C., a position he filled from the time the committee was first set up in 1946 until he left it, about two years before his case was heard by the Gray Board.

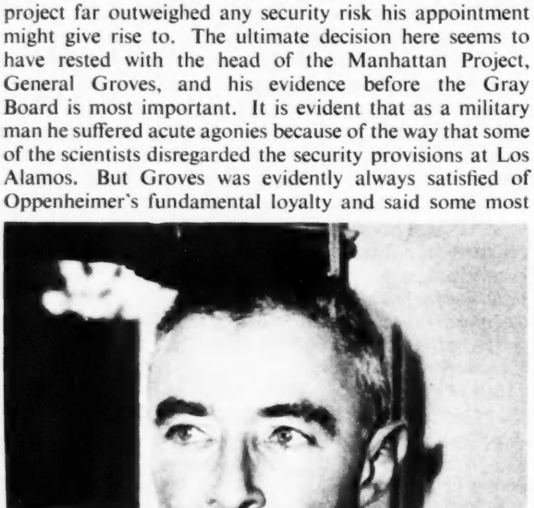
It has been argued that Oppenheimer's services could have been dispensed with quietly and without all the fuss about his fitness to continue to see the kind of secret documents he had handled quite safely for so many years. This is a doubtful proposition. A man as important as Oppenheimer could not just have been quietly dropped from official committees; had such a course been followed the slur on his name would have been no less serious, for the fact that Oppenheimer was no longer *persona grata* could not have been kept out of American newspapers. In fact, many months before the Gray Board held its inquiry the American press had carried plenty of stories to the effect that Oppenheimer's star was waning in A.E.C. circles, and this decline was connected with allegations that he had opposed the H-bomb scheme at a critical time.

The key question which the Gray Board had to consider was whether Oppenheimer was too big a security risk to be

* *In the Matter of J. Robert Oppenheimer*. Transcript of hearing before Personnel Security Board held in Washington, D.C., April 12 to May 6, 1954. This A.E.C. document was originally published by the U.S. Government Printing Office, and can now be obtained from H.M. Stationery Office, price 23*s*. 6*d*.

given access to the highest atomic secrets. Their decisive verdict on this point rested largely upon what they called his "defects of character". To reach that verdict they painstakingly went into Oppenheimer's record in very great detail. His veracity and candour came in for a good deal of study in the board's report. They spent a great deal of time collecting evidence on the Chevalier incident, and here Oppenheimer himself admitted that he had told a top security officer a "whole fabrication and tissue of lies". Inconsistencies were apparent, too, in Oppenheimer's evidence about Lomanitz. Oppenheimer's story proved inconsistent when he was cross-examined about the Seaborg letter, which should have been read (and presumably was read, though no minutes of the meeting ever existed, so this point can never be definitely settled) to the decisive General Advisory Committee meeting which discussed whether a crash programme of H-bomb development should be started.

Very relevant to the question of Oppenheimer's security clearance was his past record in connexion with security matters. Before Oppenheimer was appointed head of the Los Alamos A-bomb laboratory questions had been raised because of his political ideas and associations. But the decision was then made that his value to the A-bomb project far outweighed any security risk his appointment might give rise to. The ultimate decision here seems to have rested with the head of the Manhattan Project, General Groves, and his evidence before the Gray Board is most important. It is evident that as a military man he suffered acute agonies because of the way that some of the scientists disregarded the security provisions at Los Alamos. But Groves was evidently always satisfied of Oppenheimer's fundamental loyalty and said some most



Dr. Oppenheimer, as director of the Los Alamos laboratory in New Mexico, was a key figure in the wartime atomic bomb project. After leaving Los Alamos, he became head of Princeton's Institute for Advanced Study. His 1953 Reith Lectures on "Science and the Common Understanding" have just been published by the Oxford University Press.

important things in Oppenheimer's favour at the hearing. For example, when asked whether he thought Oppenheimer "would ever consciously commit a disloyal act", his answer was clear and categorical, and probably carried more weight with the Gray Board than any similar answers (and there were plenty of them) to that kind of question: "I would be amazed if he did", said General Groves.

Oppenheimer's attitude towards the H-bomb scheme was exhaustively examined by the board. On this issue the board has been abundantly and severely criticised, for it can be convincingly argued that it is no crime to form a wrong opinion on a controversial issue, especially since Oppenheimer's opinion was one that was matched by all the other members of the General Advisory Committee, with the one exception of Prof. Seaborg. Nevertheless the board was entitled to consider the quality of Oppenheimer's judgment in so important a matter. What Oppenheimer thought and did about the H-bomb controversy is a significant part of his record, to be balanced against his record of positive achievement. It cannot be said that this issue is relevant to the questions of loyalty and security risk; this is cogently argued by a lawyer in the September 1954 issue of the *Bulletin of Atomic Scientists*, who says that from the strictly legal point of view, evidence about Oppenheimer's record in the H-bomb controversy should be ignored on the grounds that it extends "enormously the meaning of a security risk to include the giving of bad advice and the failure to display requisite enthusiasm". (There are of course quite a few people who take a more pragmatic view of this issue; for instance James Shepley and Clay Blair in the book entitled *The Hydrogen Bomb* have this to say: "Repeatedly the point has been made on Dr. Oppenheimer's behalf that it is not criminal to be wrong. That is undebatable. It is not criminal to be wrong about the weapons of atomic age, only *fatal*.")

In many ways the details in the transcript about the H-bomb tend to confuse the central issues, but what does emerge incidentally is a fairly clear chronology of the H-bomb developments and an indication of the extent to which the perfecting of a practical H-bomb was delayed. It is with some surprise that one discovers that the Los Alamos scientists were discussing H-bombs, necessarily in a rather remote way, very soon after that laboratory was established. Dr. Oppenheimer said that in the summer of 1942 he took part in discussions about the possibility of using fission explosions to initiate thermo-nuclear reactions. At that time of course a fission bomb was a long way from being a practical reality; the first A-bomb explosion was not to take place until July 1945. When the war ended there was some desultory talk about hydrogen bombs, but nothing practical in that direction was done by Los Alamos which was America's only atomic-weapons research laboratory. Instead it put its major development effort into the design of tactical weapons. In 1947 the H-bomb idea was discussed by the General Advisory Committee under Oppenheimer's chairmanship, but there was no great sense of urgency, and nothing seems to have come out of the 1947 discussion. It was not until the month after the Russians exploded their first atomic bomb (Sept. 1949) that the G.A.C. gave urgent consideration to H-bomb possibilities. The committee had been directed to give

advice on two specific and related questions. These were:

(1) In what way should the A.E.C. programme be altered or increased.

(2) Whether a crash programme for the development of the H-bomb should be part of any new programme.

The G.A.C. went into these matters at the end of October 1949. With the exception of Seaborg, the committee was unanimous against any such crash programme, and it was Oppenheimer who went before the Joint Congressional Committee on Atomic Energy to explain that advice.

There were, however, other scientists—notably Dr. Teller and Prof. E. O. Lawrence—who took a directly opposed view on this question. There were members of the Joint Congressional Committee and of the Atomic Energy Commission who thought that Teller and Lawrence were right in believing that an all-out effort should be made to produce an H-bomb, and that the G.A.C. was wrong. This view prevailed, and in January 1950 Truman announced his decision to proceed with an H-bomb. The H-bomb programme then went ahead very rapidly.

According to Oppenheimer the G.A.C. "never again raised the question of the wisdom" of their Government's policy on the H-bomb "but concerned ourselves with trying to implement it." There is a conflict of evidence on that point, however. Dr. Teller told the board how he felt the whole time that Oppenheimer was standing in the way of the expansion of the effort on the H-bomb, and Oppenheimer's attitude in the period after Truman gave the 'go-ahead' order must have upset Teller considerably, for he went so far as to tell the Gray Board that "I would feel personally more secure if public matters would rest in other hands"—one of the hardest things said against Oppenheimer in the whole of the hearing.

Undoubtedly the H-bomb programme was delayed—and dangerously delayed it seems—and fault can be found with the kind of advice which the General Advisory Committee gave about it. The American hydrogen bomb was exploded only a few months before the Russians exploded theirs. (The U.S.A. held its first full-scale hydrogen bomb test in November 1952. The Soviet thermonuclear test was held in August 1953, and in March 1954 the Americans detonated a deliverable bomb which had a power of 12–14 megatons of T.N.T.)

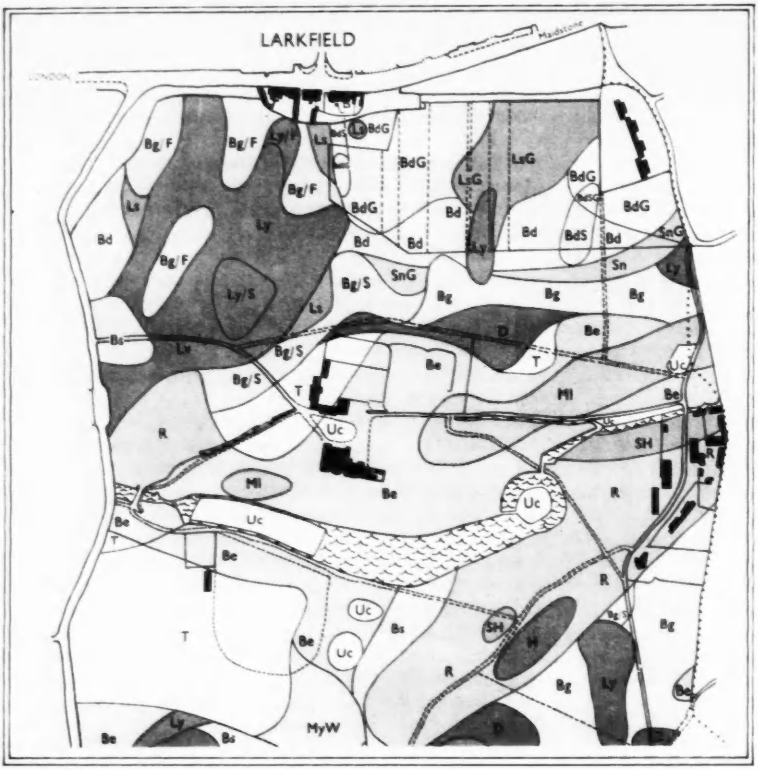
Rarely can a board of inquiry have had a more difficult task than the Gray Board. Whatever their verdict, they were bound to be criticised. The only fair way to assess their verdict is to read the full transcript of the evidence, and then to imagine oneself in the position of a member of the Gray Board with a duty to come to a just decision. Emotionally and professionally the first reaction of many scientific people was bound to have been pro-Oppenheimer; we cannot help wondering how many scientists have changed their minds about the affair after reading all the evidence.

SOIL SURVEYS

Most large industries find it necessary to know as much as possible about the raw materials they use, but the agricultural industry all over the world is sadly in need of fundamental information regarding its main raw material—the soil. Soil surveys contribute information regarding the distribution and extent of the different kinds of soils; they provide data on their properties and, where possible, correlate the behaviour and productivity of crops under different systems of management and thus assist in predicting the potential productivity of land. Much use can be made of soil surveys in helping to solve problems connected with crop growth and the introduction of new crops or new farming practices. Surveys are often instituted with a specific aim; for instance, a survey may be made to determine the suitability or otherwise of a particular piece of land for irrigated crops before it is taken over for settlement. If the survey is adequately carried out and considered, the results will assist in deciding whether or not to proceed with the scheme.

Soil surveys have been made in many parts of the world, but soil maps covering entire countries are few, for progress can only be slow and the staffs employed in such work are not large. As cultivation extends into the less well-known territories, and as primitive agricultural methods are replaced by more modern ones, soil surveys—at least, on a reconnaissance basis—are being asked for in order to delimit the amount of land suitable for the cultivation visualised. In the more arid parts of India and Pakistan, for example, such surveys are being made before irrigation projects are undertaken, and in Africa, several colonies have instituted surveys for this and other purposes. In undeveloped or underdeveloped areas, the study of air photos, combined with constant checking of the data so obtained against observations made on the ground, can provide a great deal of information regarding the soils likely to be present, but in more highly farmed lands their use is more limited and the more conventional methods have to be used; thus one collects the requisite details by traversing the area and inspecting the *soil profile* from surface to weathering rock, either in road-cuttings, holes dug for the purpose or by auger borings.

Many years ago soils were classified in various ways—e.g. by their texture (sands, clays, marls, gravels, etc.) or from a comparative study of the geological formations on which they were found, but great advances were later made under the influence of the Russian methods of studying soils which became generally available after the 1914–18 War. More attention was then paid to the whole profile, instead of the arbitrary 'surface' and 'subsoil', and to its development in the landscape, from which it cannot be divorced, and to recognising the similarities between soil profiles. In Britain consideration of the rocks or materials from which soils are formed has greatly influenced soil studies, particularly since the Geological Survey had already produced maps of the various geological formations which, especially in southern England, corresponded to soil differences over large areas. But, as is well known, the soils existing on top of the same geological formation or beds can differ considerably because of the influence of texture (either of the parent rock or the soil), relief, drainage or climate. It is these factors, together with other factors and soil properties, that the soil survey includes in its descriptions of *soil series*, which is the term applied to groups of soils of similar morphology developed under similar conditions or from similar parent materials. Soil series form the basis for mapping soils. The individual soil



Counterparts of the geological maps prepared by the Geological Survey will be the series of soil maps planned by the Soil Survey of Great Britain. A series of one-inch soil maps are to be prepared, and the first—covering the Wem district of Shropshire and corresponding to Ordnance Survey Sheet 138—has just been published. Different soils are shown in different colours; an impression of what a typical soil map looks like is conveyed by this reproduction of part of the large coloured soil map of the ground occupied by the East Malling Research Station.

units can be assembled in various ways to form higher categories with common properties which extend over larger areas, or they can be broken down so that maps of selected properties for different purposes can be made. Soil maps are therefore of use to the administrator, who frequently has to consider large areas, although their main use is as a basis from which the agricultural adviser can make recommendations.

The earlier British surveys were concerned with showing the differences in the texture of the surface soil, but it soon became apparent that these differences were insufficient to account for crop behaviour and that study of the whole profile was needed. Surveys that were carried out in intensive fruit-growing and market-gardening regions in Hertfordshire, Worcestershire, Cambridgeshire, Kent and Hampshire clearly showed this, and the information gained during these surveys has provided a sound basis "for advising on the suitability of soils for the growing of different classes and even different varieties of fruits and enable forecasts to be made of the main problems that are likely to occur on the various soil types".

In the realm of plant nutrition, disorders in crops have been related to the excess or deficiency of trace elements and these have been correlated with certain soils. Soil surveys have proved valuable in the field of animal husbandry where certain disorders can be traced to the excess or deficiency of trace elements in the soil which results in the herbage being less nutritious than normal for the animal. For instance, investigations in Somerset showed that 'teart' disease of cattle was linked with an excess of molybdenum in the soil, which was taken up by certain pasture plants and hence caused the disorder. 'Pining' of sheep in Scotland and Devonshire has been found to result from deficiency of cobalt, and to be associated with soils derived from certain rocks. Copper deficiency in both peat and mineral soils leads to the condition known as 'swayback' in Derbyshire or 'reclamation disease' in Holland and New Zealand. Selenium in certain soils of the U.S.A. can be so excessive as to cause the death of animals which eat the selenium-tolerant plants. The benefit of making soil surveys in such areas where considerable financial losses may be incurred does not need to be stressed.

Correlation of plant or animal disorders and soil properties are a dramatic application of soil surveys, but their general application is more humdrum. In order that agricultural progress can be maintained, both here and overseas, field experiments are necessary, but hitherto in such experimental work little account has been taken of variations in the soil itself. Surveys—some in considerable detail—have now been made of the farms used for experimental work by the National Agricultural Advisory Service as well as those belonging to agricultural colleges and institutes. These surveys enable it to be said with more certainty how crop yields have been affected by a particular procedure, and sounder recommendations can then be made.

No one can fail to be struck by the differences between

the woods and forests in different parts of the country, and by the behaviour of various forest trees growing on different soils. While vegetation may usefully reflect the surface soil condition, it does not necessarily provide any significant information about the sub-surface layers, which are of great importance to root growth. There is a great deal of interesting work to be done in correlating the results of ecological studies and soil surveys which has application to forestry.

Since the 1939–45 War it has been realised that the amount of land used for buildings, airfields and so on represents a serious and complete loss to the agricultural industry, and efforts are being made to reduce this as much as possible by so siting new towns and buildings that as little good agricultural land as possible is destroyed. Essays in land classification for this purpose have required soil surveys to be made, either of limited areas around towns (such as is provided in "A Plan for Plymouth") or of regions (e.g. "English Country" and "Conurbation", a study of the region affected by the growth of Birmingham or of counties such as was undertaken for Gloucestershire, Somerset and Wiltshire by the University of Bristol).

Enough has been said to indicate the many and varied ways in which soil surveys can contribute both to the progress of the agricultural industry and less directly to the well-being of crops, animals and people. The land is a national resource and of limited extent: it is therefore necessary if a high standard of living is to be maintained that the best use should be made of it. Neglect or ignorance of good principles of agriculture and particularly of soil conservation has in good measure been responsible for the decline in productivity of large areas of the earth's surface, and it is only by using every means at our disposal that its productivity can be maintained and increased.

(The illustration to this note is based on the map published in the 1953 Annual Report of East Malling Research Station. The soil survey providing the data for that map was collected by B. S. Furneaux, a governor of East Malling, and a consultant soil surveyor by profession.)

TRITIUM IN NATURE AND IN THE RESEARCH LABORATORY

Tritium, the isotope of hydrogen which has an atomic weight of 3, has ceased to be a great rarity since the American H-bomb project got under way. Tritium is one ingredient of the fusion bomb, and is being prepared in large quantities in the U.S.A. by irradiating lithium with neutrons in the dual-purpose atomic piles of the Savannah River plant. Information about this aspect of the tritium story will doubtless remain classified for a long time to come, but in sectors far removed from the explosive use of tritium a fair-sized literature on the use of tritium as a radioactive tracer is accumulating and some very interesting work has been done on the distribution of naturally occurring tritium.

The discovery that tritium occurs in nature was made comparatively recently, and this is the reason why one still meets brand-new books which offer the categorical but erroneous statement that "tritium is not found in nature". Tritium occurs in the form of tritium oxide, which is present in minute quantities in all rain-water. The present view is that it is generated in the upper atmosphere by the action of cosmic rays.

The half-life of this radioactive isotope of hydrogen is about twelve and a half years. If it is assumed that the tritium-containing water does not stay in the air long enough to decay appreciably, then the total rate of production of tritium in the atmosphere can be calculated from measurements of the tritium content of rain, river water and sea-water. A paper dealing with this aspect of tritium was read at the recent national meeting of the American Chemical Society by Prof. W. F. Libby of the Institute for Nuclear Studies and the Department of Chemistry at Chicago University, who is possibly best known to readers as a great authority on the dating of archaeological and geological specimens by the radio-carbon technique.

He stated that the production rate for tritium in the atmosphere averages out at about one tritium atom per second for every square inch of the earth's surface. The surface water of the oceans contains about one-fourth of the tritium present in the rain falling on the sea. This fact led Prof. Libby to consider the extent to which the rain mixes with the sea-water, and this is the conclusion which he reached:

"One deduces that the surface layer of the ocean does not mix very efficiently, and in fact that the average mixing depth for the life-time of tritium is only some 50 metres."

Study of his data on the tritium content of various samples of rain-water resulted in another interesting observation: that the rains over the continents are richer in tritium than the rains over the oceans. The explanation of this fact is that the water raining over the continents has spent a longer time in contact with the atmosphere and therefore it has had a greater opportunity to become contaminated with cosmic-ray tritium since it evaporated from the ocean.

The rate of tritium production in the atmosphere must vary with the amount of cosmic-ray activity, and Prof. Libby has suggested that this fact might be exploited to get some information about such activity in specific years in the past. The problem is, of course, to find samples of water which were bottled in specific years. Prof. Libby had the inspiration of using bottles of wine of known vintage; by measuring the tritium content of a specific sample of wine, and then correcting that figure to allow for the amount of radioactive decay of the tritium that has occurred in the intervening years, he was able to get a figure for the tritium content of the wine when it was originally laid down. That figure would approximate very closely to the tritium content of the rain that fell on the vineyards in the year that the wine was prepared. The tentative conclusion which Prof. Libby has drawn from some initial tests on vintage wines is that "the present tritium content of the rains falling in the vineyards in New York State and in western Europe which were used for the tests is the same as it has been over the last decade or so".

In biochemical research tritium promises to be a very useful radioactive tracer. It is already being used by quite a few chemists and the term 'tritiated' is already well established to describe compounds containing tritium instead of ordinary hydrogen atoms. The Second Radio-isotope

Conference sponsored by Harwell and held in Oxford this July included one paper dealing* with this aspect of tritium.

THE NRDC-RICARDO LIGHT STEAM ENGINE

Two years ago a committee under the chairmanship of Sir Edward Bullard, director of the National Physical Laboratory, reported on the possibilities of utilising solar energy for power purposes. Their report (which was published in *Research*, November 1952, pp. 522–9) was largely concerned with the exploitation of solar energy fixed by plants, and in particular it considered the idea of fermenting vegetable matter to produce alcohol for use in internal combustion engines, and also the possibility of developing an efficient steam engine of small size which could be run on wood.

The report stated that "it does seem desirable that a small steam engine fired by vegetable matter should be designed. It is possible that such an engine might be of value in some areas where coal and oil fuel are not available, but wood or other suitable plants are." Such an engine has now been perfected, under a development contract put out by Britain's National Research Development Corporation. The engine was the invention of Sir Harry Ricardo, and his design represents a pretty solution of a far from simple problem—for as the head of the National Research Development Corporation, Lord Halsbury, pointed out at the first public demonstration of the new engine, "the problem was not merely to produce a steam engine but a steam engine *and its boiler* at a price which would compete economically with a diesel engine".

It was the power needs of India which originally prompted the development of this engine, and the value of the invention is best judged against the power requirements of India and other such countries. Lord Halsbury has given a few statistics which illustrate what such a supply of power would mean to one of India's villages—which number about one million! At present these villages have no access to power other than the power of human or animal muscles. In Lord Halsbury's words, "If one 5 h.p. diesel engine for a village was installed and operated for 24 hours a day for 365 days in the year, the import fuel bill to be met on settling day would be £125 million per annum. You can divide this by any factors you please to convert a 24-hour day to some less onerous period of work and to make provision for holidays. You can also multiply it by whatever factor you please in order to provide a village with the number of 5 h.p. engines you think a village ought to have. Whatever your conclusions may be, however, they cannot amount to less than multiples of tens of millions of pounds —and India is not a country which can import without regard to her capacity to export."

The Ricardo engine—which is actually a $2\frac{1}{2}$ h.p. engine but is capable of scaling up to 5 h.p.—is a source of power which can be operated in complete independence of any imported fuel. It can be run on almost any fuel—under the boiler one can burn oil, gas, coal, low-grade coal, peat, wood, brushwood, sawdust or dung, whichever of these is most conveniently accessible. Thus it is capable of 'living off the land'. The Indian villager would want to compare its efficiency with that of a bullock; here it can be said that the area that would need to be reserved to grow fuel for this engine would be very much less than that required as pasture for beasts producing the equivalent amount of power. If an acre of, say, sugar-cane were burnt in this engine it would supply enough power to irrigate 15 acres of waterless land—which is a fair index of its utility.

The small steam engine suffered an eclipse with the coming of the internal combustion engine running on petrol and diesel oil. But there are plenty of places where ample supplies of petrol and oil cannot be made available at a low price, and in such places there seems a great future for small steam units. Now that Sir Harry Ricardo, the high priest of the internal combustion engine, has applied his talents to designing a light steam engine for N.R.D.C. other ingenious designers may well follow suit, to the infinite benefit of the backward areas of the world which so badly need a cheap source of power.

Almost certainly one or more manufacturers will take up the Ricardo steam engine, and produce it under licence. We anticipate that some readers will want more information about this engine, but until it is in commercial production it would at present be best if all such inquiries were sent direct to the National Research Development Corporation (whose address is: 1 Tilney Street, London, W.1).

AN OCTOPUS INVASION

It is a rare occurrence for octopuses to invade British waters in great numbers. In fact this has only happened twice in the past sixty years. The first of these two 'octopus invasions' dates back to 1899–1900. The second was in 1950, and a full account of this invasion has now been published in the *Journal of the Marine Biological Association*. The authors of this paper are Dr. W. J. Rees of the Natural History Museum, and J. R. Lumby of the Fisheries Laboratory at Lowestoft.

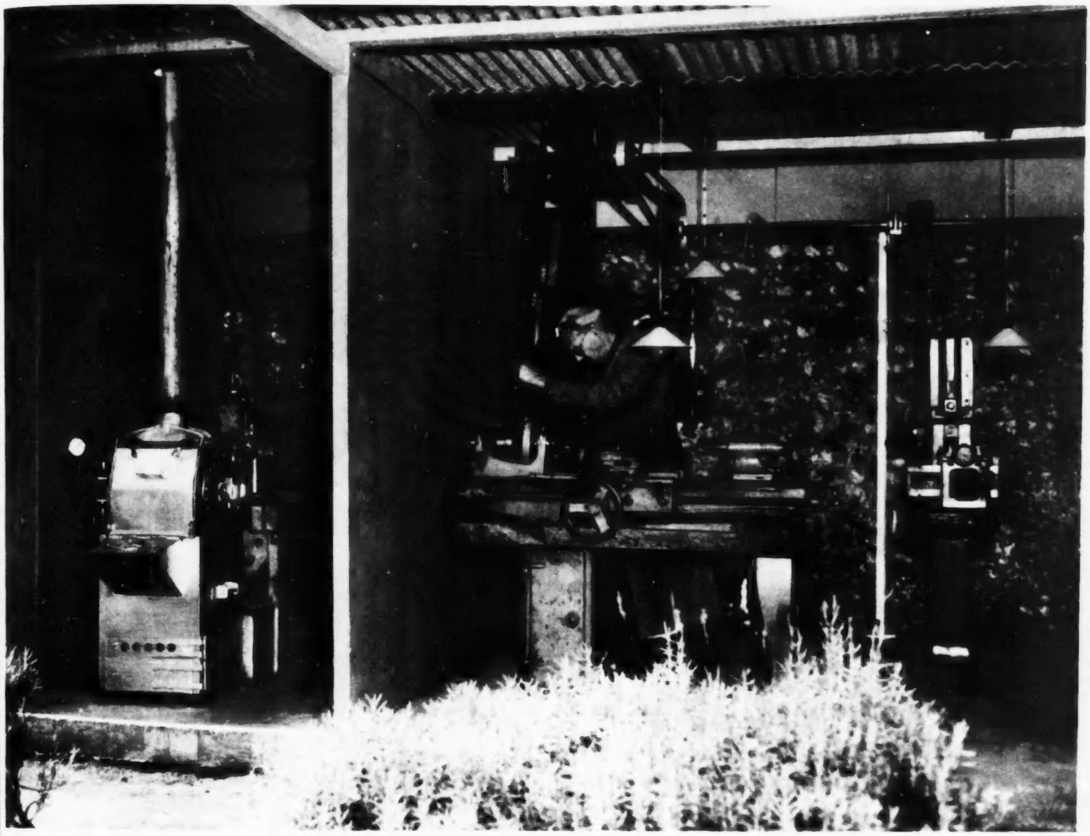
There was no clear evidence at the beginning of 1950 that the invasion would soon strike our shores, though the abundance of octopuses in the Channel Islands in January was a hint that a repetition of the events of 1899–1900 was a distinct possibility.

Plankton hauls taken the previous year by the research vessel *Sir Lancelot* had picked up octopus larvae well away from the animal's usual breeding grounds, and it was considered that they had been dispersed by warm water movement.

During January, February and March 1950, the first large migration of the young stages was gathering impetus and moving eastwards from their breeding grounds towards our south-west coast. Then in March 1950 an occasional juvenile octopus was caught by the research vessels of the Marine Biological Association off Plymouth. One of these specimens measured approximately two and three-quarter inches along arm-span and must have been spawned during the previous July or August.

The invasion was now well under way, but it was only the small ones that were being taken. Crab and lobster fishermen along the coasts of Devon and Cornwall carried on their work, unaware of the menace approaching from

* This paper, by Dr. R. Glascock, can be consulted in the proceedings of this conference published by Butterworths Scientific Publications under the title *Radio-isotopes Conference: 1954*; see also Dr. Glascock's new book *Isotopic Gas Analysis for Biochemists*.



At the recent demonstration at Sondes Place of the NRDC-Ricardo steam engine, a rural workshop powered by the 2½ h.p. unit was on show. This exhibit is seen in this photograph, which shows the engine driving through lineshafting, a six-inch lathe, a post drilling machine, a combined shaping and slotting machine, a power hacksaw, and a bench grinder.

the south. Then one day in the third week of May, Skipper T. Harvey, of Torquay, took the trawler *Girl Vine* on a routine journey. He worked a position some twenty miles south-east of Berry Head in Devon. In one haul the cod-end of the trawl was filled with octopuses, and these were all large ones measuring 3 ft. in arm-span. Skipper Harvey continued with his trawling, and a few more specimens were netted in the area. Fourteen days later, the octopuses had disappeared from these grounds, and where they had gone to remained a mystery for some time. Later events proved they had moved inshore.

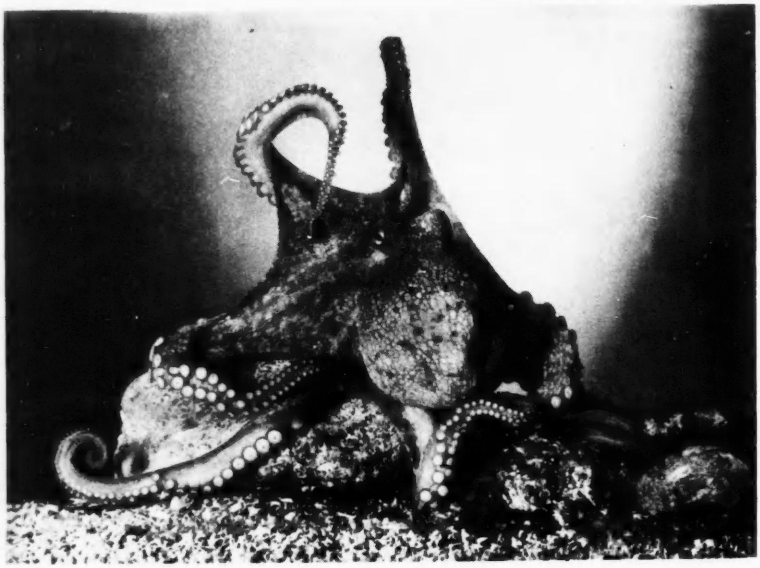
It was now that the real extent of the 'invasion' began to become clear. During the last week of that May, a specimen with an arm-span of thirty inches was taken at Bexhill from a crab-pot. In the first half of June, the coast of Devon from Babbacombe Bay to Beer and Seaton received the full onslaught. Fishermen at Babbacombe Bay discovered octopuses were taking crabs and lobsters from their pots, and soon these same men were taking as many as 30 to 40 octopuses a day from their pots. At Beer and Seaton the shellfish industry was almost stopped by the creatures. As far west as Plymouth, fishermen abandoned their crabbing because of the theft of crabs from their pots.

One day in August, a large number of octopuses entered Dartmouth Harbour, and they were so numerous that many were taken on hook and line. In size they measured up to 4 ft. across their arm-span.

In mid-August specimens with a 2½–3 ft. arm-span were being caught by anglers at Brighton and Eastbourne, and some up to 4 ft. 6 in. were taken from lobster pots on Hoo Bank of Selsey Bill.

Thus we see that the invasion force had spread to affect the whole of the Channel. By September 2 it had reached Deal, where a specimen was taken that is now in the Natural History Museum; this is one of the few octopuses ever recorded from the North Sea.

Throughout the autumn, the main body of octopuses remained close inshore, and one fisherman from Plymouth who had seen only four octopuses in thirty-five years of



The Common octopus (*Octopus vulgaris*). This specimen was photographed in the Plymouth Aquarium by Dr. Douglas P. Wilson.

fishing, caught no fewer than fifty by the first week of October.

The main breeding grounds of this animal are known to be in the south-western area of the Channel and around the Channel Islands. Records indicate that hatching begins in June on the north coast of Brittany, but by July the larvae are common around the Channel Islands.

There is no indication that they breed in the inshore waters around our coast to any large degree. This species of octopus is believed to spawn only quite close inshore, within the ten-metre depth line.

During the course of this work, one larval specimen was taken off the Cornish coast, but unfortunately it is not possible to establish whether this one did, in fact, hatch from a spawning there or was carried by currents from the mouth of the Channel.

Biologists have considered the role of sea temperature and its influence on spawning, and it has been observed that outbreaks always follow years of high winter temperature.

As already stated, there are signs of a definite migratory movement in some years, and observations from the Channel Islands show the following. According to J. Sinel, "in the autumn in Jersey, they sometimes swarm on the surface. Men armed with long bamboo rods, with large hooks at the end, station themselves on outlying rocks, and simply hook them out as they pass. I have seen many tons weight caught in this manner, and being used for manure on the land."

This southerly movement has not been established as an actual migration however. Generally speaking, there is an inshore movement during the summer and a corresponding retreat into deeper, warmer water in the winter.

The 'invasion' of 1950 may well have been caused by the tremendous numbers of octopuses on the French coast. With the consequent lessening of available food, many would then commence to move outwards and eventually arrive off our shores.

A plague year of octopuses causes considerable hardship among the fishing communities along the Devon and Cornish coasts. Wherever octopuses are numerous, the lobsters become very reduced in numbers. Since their principal food consists of crabs and lobsters, the creatures will be most numerous on the good fishing grounds. Lines of lobster pots, provide the ideal larder for them, and with long tentacles they will rob a pot of every shellfish.

Lieut.-Commander C. A. Hoodless, D.S.C., master of the research vessel, *Sabella*, has reported that in 1950 the vessel was making an average of eleven hauls a month, and the first record of octopuses was on September 4. From that date lobsters almost completely disappeared from the trawling grounds.

A note by Prof. J. Z. Young says—he is speaking of the 1950 'octopus-plague year' in the area around Cherbourg— "At Ormonville. . . . There is a little harbour there and the jetty runs along the rocks. Looking down among these we could see a great number of octopuses moving about in the water at high tide. For instance, at one moment we counted no less than twenty-five in sight, even though the water was rough and visibility was limited to a few yards."

It is highly probable that there is always quite a large population of the creatures inhabiting the Channel, but that they only become a serious menace after a warm winter.

The largest specimen found during the investigation had an arm-span of 5–5½ ft. Growth rate is fairly rapid, and specimens of 2½ ft. are reckoned to be less than two years old.

So much then for the octopus that turns up on British coasts. Whilst this species is no menace to the unsuspecting bather, it can be a great enemy of the commercial shellfish fisherman, and can cause a complete temporary collapse of the industry in 'invasion years'.

THE HIBERNATION OF ANIMALS

L. HARRISON MATTHEWS, Sc.D., F.R.S.

Most animals are cold-blooded: in all the invertebrates, and in the vertebrates except the birds and mammals, the temperature of the body is approximately the same as that of the surrounding medium, rising and falling in harmony with its fluctuations. All animals that live in the sea are subjected to a comparatively small range of temperature variation that is not great enough to preclude an active existence throughout the year. Even in the sea, however, many of the inhabitants of the upper strata and of shallower waters show seasonal outbursts of activity (mainly in connexion with reproduction), and the feeding activities of a great number of species are restricted during the colder times of winter. But animals living on land with air as the surrounding medium, particularly those that live outside the tropics, are subjected to a far greater variation of temperature with the course of the seasons, and have been forced to adopt various means for coping with it. Hibernation is one of them.

In cold-blooded animals the metabolic rate varies, being greatest at high temperatures, and least at low ones. No animal can long withstand a temperature of much over 100°F; for one thing, the proteins of the tissues are coalgulated by great heat—though most animals could not survive even up to the temperature necessary for that to occur. Members of only a few groups, in which there are special arrangements for resisting frost, can withstand being frozen. With the onset of the chill of winter cold-blooded animals must therefore seek out some sheltered spot to which frost will not penetrate where they may safely remain until warmer conditions return. But many go further than this and enter into a state of torpidity in which the metabolism is reduced to the absolute minimum consistent with the preservation of life. Most people have at some time seen a queen wasp hibernating, perhaps behind a picture on the wall of an unheated room, where it hangs motionless from some projecting shred which it grasps in its jaws, while its legs, wings, and antennae are folded down on the underside of the body just as they were when the insect was a pupa. In many insects there is a special kind of hibernation—*the diapause*—in which the life history is interrupted by the hibernation of an immature stage. Thus some species pass the winter as eggs; others do so as partly-grown or fully-fed larvae, or as pupae. The diapause, however, is not necessarily a winter phenomenon. Numerous other invertebrates likewise have their own methods of hibernation; snails, for instance, creep into some sheltered cranny, and shrink as far as possible into the shell after making a door of hardened mucus to close its mouth.

Many of the cold-blooded terrestrial vertebrates similarly hibernate in some protected spot, often underground, where they remain motionless with all their activities reduced to a minimum. It is well known that frogs hibernate, though few people know where or how they do it—in actual fact, they bury themselves in the earth, or in the mud at the bottom of ponds and ditches. Toads and newts generally hibernate on land, tucked away in some crevice underground; one very rarely comes across them, and it is a matter for wonder that so many millions of them can be concealed all over the country every winter without being more frequently discovered. Snakes and lizards, too, are expert at lying up in some underground den where they are safe from molestation. Adders in particular like to take up winter quarters in crevices among the foundations of a dry wall, and when they wake after the winter they may often be seen basking in the early spring sunshine on some favourite warm stone before the growing herbage shoots high enough to conceal them from view.

Even some of the marine fishes cease their usual activity in the winter, become torpid, and undertake a sort of hibernation. They are mostly those species that live upon the plankton, the mass of floating 'water fleas' and other small animals and plants that swarm in such incredible quantities in the upper strata of the sea during much of the year. The basic organisms of the plankton are the diatoms, minute unicellular plants that start multiplying in countless millions with the lengthening hours of sunshine in the spring. Just as all flesh is grass, so all fish is diatom, for when this outburst of plant growth comes in the spring the herds of copepods and other minute floating crustacea increase enormously and graze down the rich feeding that is provided for them. Some of the larger fishes—and the whalebone whales too—are specialised for feeding upon this great abundance of animal life when it becomes available to them, and they filter out the swarming plankton as they swim through the sea water; among the fishes the mackerel and the Basking shark may be particularly mentioned here. But after the brilliant days of summer the mineral resources of the sea necessary for the growth of plants are temporarily depleted, and with the onset of the shorter days of winter the diatoms die down; when they decrease in quantity the exuberance of animal plankton fades away, leaving the filter-feeders short of rations. The teeming shoals of mackerel leave the upper strata of the sea and retire to deeper water where they lie inert waiting for the return of more favourable conditions in the spring: it is then that the fisherman make their great catches of trawled mackerel, sweeping up the shoals that lie torpid near the bottom.

Even the enormous Basking shark, that may weigh up to three or four tons, is entirely dependent on the plankton for its sustenance. Throughout the summer months it basks in the sunshine of the upper strata of the sea, cruising along at about two knots and filtering out many tons of plankton from the sea water as it slowly forges ahead with its mouth wide open; thus the plankton is left stranded in the pharynx on the elaborate arrangement of gill rakers carried on each of the gill arches. But when the summer outburst of plankton dies down there is not enough food for these enormous animals, and they disappear from the surface waters. No one knows where they go, but recent research has thrown much light upon their probable whereabouts.

It was long believed that Basking sharks migrated to distant or deeper waters during the winter of the temperate regions, in spite of the fact that specimens are occasionally stranded or sighted even during the depths of winter. Within the last few months new and startling information has been reported upon this subject. Careful investigation of a number of winter-caught Basking sharks has shown that they do not possess gill rakers—that they are, in fact, without the means of obtaining their characteristic food. It is evident that with the approach of winter the Basking shark sheds its gill rakers so that it is thereafter incapable of feeding, and that a new set of rakers slowly develops during the winter to erupt like another dentition in the spring. It is thus almost certain that the Basking shark hibernates during the winter, as it cannot feed and is therefore incapable of any sustained activity. At this time of the year it probably retires to deeper water—perhaps seaward of the continental shelf—and then, like the mackerel, it proceeds to lie on or near the bottom in a state of torpidity with all its metabolic processes reduced to the absolute minimum; there it stays until the next year's crop of plankton provides a pabulum which its newly-grown gill rakers can collect.

Parker and Boeseman have recently shown that when the plankton is reduced to its minimum during the winter there is not enough of it in each cubic metre of water to supply the energy necessary to keep a Basking shark swimming at even the slowest speed at which it can filter its food out of the water—if a shark were to continue feeding during the winter it would lose on the deal, for the energy produced by the plankton it could obtain would be less than that expended in the effort of collecting it! The shark therefore throws its gill rakers away, descends to the bottom in some quiet spot, becomes more or less torpid, and probably uses the stores of oil accumulated in its enormous liver as the source of energy to maintain a minimum level of vital processes until next summer when its feeding grounds are re-stocked.

It is, however, by no means certain that during the winter the shark draws upon the oil stored in the liver; there is justification for scepticism about this physiological question after the discovery that hibernating amphibia and reptiles do not utilise what appear at first sight to be their obvious reserves. In these animals a deposit of fat accumulates when they are not hibernating; it is laid down in special organs known as the 'fat bodies', which are situated in the abdomen near the sex glands in the amphibia and near the under wall of the abdomen in the reptiles. But the energy needed to maintain the reduced metabolic rate during hibernation is derived not, as might be expected, from the stores in the fat bodies which appear to be reserved for the activities of breeding, but from the glycogen stored in the liver and muscles.

A BIRD THAT HIBERNATES

Most of the warm-blooded animals are able to meet adverse conditions without hibernating. They are well covered with fur or feathers to keep out the cold, and are able to find sufficient food to maintain their metabolism at its full level even in the depths of winter. Until recently it was believed that no bird hibernated, in spite of the ancient legends about swallows lying dormant conglobated in the mud at the bottom of ponds; the insectivorous species whose food disappears in winter nearly all migrate to regions where it may still be found. But since the war an American naturalist has discovered one of the most startling facts to be reported in ornithology during the last hundred years—he has found a bird that undoubtedly hibernates. Far away in the Chuckawalla mountains of the Colorado desert of California at the end of December 1946, he came across a specimen of a species of nightjar, Nuttall's Poorwill, hibernating in a state of torpidity in a rock crevice of a deep canyon among the hills. The Poorwill is an insectivorous summer migrant to parts of the southern United States whence it departs at the onset of winter to regions unknown. The new observations show that it does not go to the happy feeding grounds of the tropics where insect food abounds at all seasons, but it gives up the struggle for existence and takes the soft option. The bird found in the mountain canyon was sitting inert in its shelter, its respiration and heart rate reduced to so low a level that they could not be detected with the portable apparatus available in the field, and its temperature down to more than 40°F below that normal for its active state. A ring was placed upon this bird's leg so that it could be identified, and for four successive winters it was found dormant in the same niche of refuge.

THE NOCTURNAL TORPIDITY OF HUMMING-BIRDS

Although the Poorwill is the only bird that is definitely known to hibernate, there are others that go some way towards the reduced state of metabolism characteristic of hibernation. The humming-birds that are the incarnation of activity during the heat of the tropical day relinquish their intense metabolic activity when they go to roost; their temperature drops and their rates of respiration and heart-beat fall—and this happens in some species not only when they sleep at night but even when they perch for an extended period during the hours of daylight. The metabolic rate of animals varies inversely with their size; the larger the slower. The daytime resting metabolic rate of those species of humming-birds in which it has been measured is higher than that recorded for any other animal, and during active hovering it is about six times greater than the rate at rest. But during the nocturnal period of torpidity it falls to about one-twelfth of the resting rate, and the birds become cold, immobile and incapable of flight.

The humming-birds are not the only kind of birds that enter into a spell of torpidity when they are not in active movement. Dr. David Lack has recently shown that nestlings of the common swift become torpid when weather conditions are such that their parents cannot obtain the supply of insects necessary for feeding their broods; their temperature falls and they enter upon a state similar to the hibernation of the Poorwill until more favourable conditions return. The nestling swift can withstand many days of fasting that would be fatal to the nestlings of most birds, and while it is denied the usual source of food its weight steadily falls as it uses up the energy obtainable from its tissues to maintain the bare minimum rate (the *basal rate* as it is called) of metabolism. It is particularly significant that the ornithological systematists have, on purely

morphological grounds, classified the swifts, nightjars and humming-birds as closely allied families. The ornithologist who investigates the metabolism of the common European nightjar during its daytime period of inactivity will probably obtain some very interesting results.

Very few mammals hibernate, and it is peculiar that among the exclusively insectivorous ones most of the bats, which during the winter must either migrate, starve or hibernate, take the last alternative, whereas they might have been expected to choose the first, seeing that they are the only mammals capable of powered flight. A few species of bat, particularly in America, do migrate southwards in the winter, but the majority of those inhabiting the temperate regions hibernate; nevertheless, their hibernation is by no means so complete as was once thought, for many species wake up at intervals and not only move about in the caves in which they pass the winter but go outside and fly from one shelter to another.

DORMICE AND HEDGEHOGS

A hibernating mammal like the dormouse rolls up into a ball when it becomes torpid, the head being bent down so that the chin rests on the abdomen. The hind feet are curled forward about level with the nose, and the hands, clenched into fists, are held either under the chin or alongside the cheeks. The eyes and mouth are tightly closed, the ears folded back downwards close to the surface of the head, and the tail is tucked forwards between the legs, its tip wrapping over the face and back. The body temperature is so low that the animal feels cold to the touch, and the muscles are held rigid so that the creature can be rolled along a flat surface without disturbing its pose. Dormice hibernate from September to April, but their sleep is not necessarily uninterrupted; their record for continuous sleep is six months and twenty-three days. Hedgehogs are much less regular hibernators, and often do not lie up for the winter until the end of the year, so that they may not be torpid for more than three months. Bats of the temperate regions vary; some species may hibernate for over five months, but here again many of them awake at intervals during the winter.

Hibernating mammals are aroused by warmth; extreme cold may also produce this effect. None of them, however, can normally withstand being frozen, hence the necessity for them to lie up in the protected nest of the hibernaculum where frost is excluded. Although bats make no nests, they hibernate in places such as caves where the temperature is fairly constant and, low as it may be, never drops to freezing. The alpine marmot and many allied species enter upon a true hibernation, but bears, contrary to popular belief, do not. Bears 'den up' for lengthy periods during the winter, but they do not become truly torpid, and their normal basic rate of metabolism is maintained throughout their sleep; it is in the winter den that the cubs are born, and there that the mother nurses them for some weeks 'licking them into shape'. Similarly the badger may lie up for several successive days in extremely cold weather but it does not hibernate in Great Britain—what it may do in northern Europe has not yet been definitely ascertained.

Although hibernating warm-blooded animals are generally unable to withstand being frozen, recent work on the

FIG. 1. Hibernating Dormouse.

subject has shown that some species at least can be cooled to temperatures a few degrees below freezing point. When this process is carried out under the correct conditions a state of supercooling is attained in which the temperature is below 0°C, and the animal can be brought back to life on raising its temperature with suitable precautions, although it cannot revive spontaneously. But great care has to be taken not to disturb the supercooled state, for even a slight shock causes immediate crystallisation of ice to begin throughout the body, and when that has happened completely there is no return. Cooling to spectacular subnormal temperatures, though not to anything approaching freezing, has recently been used as a form of anaesthesia for the performance of surgical operations*—a technique that appears to be fraught with the greatest dangers in view of our present very inadequate knowledge of this new subject.

In warm-blooded animals the approach of the cold-blooded state of hibernation makes itself felt some time before its actual onset, and the animals react by making provision accordingly. Terrestrial mammals prepare a winter den or burrow of some sort, usually lining it with dry vegetation to form a snug nest; and even among the bats many species leave their summer haunts and withdraw to special hibernating retreats which they do not inhabit during the rest of the year. But hibernation is often interrupted—the dormouse, the marmot and others, lay up stores of food in or near the nest which are, presumably, eaten when these animals, like the bats, awake at intervals. The onset, too, of winter torpidity is very irregular in many species; in the hedgehog sleep may last for only a few days at a time, with intervals of activity, until the winter is well advanced.

* This technique is described in Chapman Pincher's article on pp. 443–6 of this issue.

THE LONG LIFE OF HIBERNATORS

In the dormouse, and even more in the bats, normal summer sleep passes some way towards the torpid state characteristic of hibernation, as in the humming-birds and possibly some others. So great is the difference between the active and resting metabolism in a bat that one hour of activity uses up as much food or fat-stores as are used in more than twelve hours at the torpid rate. When bats are active their appetites are voracious, and were they active all the time they would, like shrews, need to eat their own weight of food daily. But the long periods of sleep spare them this necessity, and allow for the expenditure of the energy needed during flight, for most insectivorous bats are active for only a few hours at dusk and dawn. And there is a further result: the life span of a shrew is not more than eighteen months, but that of a bat of similar size is seven or eight years or more. When it is remembered that some species of bat spend up to nine-tenths of their summer life in torpid sleep, and all of the winter in hibernation, it can be readily appreciated that the animal machine will not wear out so quickly as in animals that are active for a higher proportion of the twenty-four hours all the year round.

Hibernation in a warm-blooded animal is a very much more drastic process than in a cold-blooded one: the animal has in effect to relinquish its temperature regulation and become cold-blooded. All hibernating mammals get very fat before entering on the winter sleep, and the fat deposits not only serve to keep the metabolism going at its reduced rate during the winter, but their presence in the autumn provides, or helps to provide, the stimulus that starts hibernation, though the means by which they do so are not known. Low temperatures and scarcity of food are not the primary causes. Similarly in some kinds of wild bee the young queens that will found the new colonies of the following year start their hibernation almost as soon as they emerge from their brood cells in the middle of the summer; and swifts leave this country on their southern migration in August when the supplies of insect food are the greatest—these things are brought about by the *internal condition* of the animal and not in the first place by the state of the environment.

Mammals have a deposit of dark-coloured fat and lymph tissue round the blood vessels in the neck, chest and elsewhere, in addition to the general fat stores; it is particularly prominent in hibernating mammals. This deposit is large in the autumn but decreases to very small proportions by the middle of the following summer. This 'brown fat' has been termed the 'hibernating gland', but its functions are obscure, for it decreases in size during hibernation more slowly than the general reserves of fat.

When a hibernating warm-blooded animal becomes cold-blooded and undergoes a decrease in temperature the rate of respiration also decreases. A torpid bat for example breathes about 25 to 30 times a minute for some three minutes and then pauses for three to eight minutes without breathing; its normal rate during active periods goes up to about 200 a minute without any pauses. In some species the rate during hibernation is lower still, so that it is very difficult to detect any sign of breathing at all. At the same time the rate of the heart-beat becomes very slow and the circulation is further retarded, in some bats at least, by the spleen swelling up to about seven times its normal volume, being distended with blood and acting as a reservoir for the main bulk of the blood while it is not being vigorously pumped around the body by the heart.

During hibernation the blood itself is altered in composition. Experiments on hedgehogs have shown that in hibernation the amount of sugar in the blood is less than half that present when the animal is active, but the amount of magnesium is more than twice as great. It has further been found that if active hedgehogs in summer are injected with insulin, which decreases the amount of blood sugar and increases the magnesium, and are placed in a low temperature (but above freezing) an artificial hibernation is induced which may last for many days. When such animals are later removed to a warm temperature they awaken in a normal manner and return again to the warm-blooded state.

There seems to be some doubt about the temperature of the body during hibernation, for most observers have recorded very low figures by taking the rectal temperature; but if the temperature of the blood within the heart is measured, an operation that can be done with a small thermocouple mounted in a fine hypodermic needle, much higher values are found. There appears to be a temperature gradient, the extremities being very cold but the centre remaining considerably warmer. It is interesting to note in this connexion that when non-hibernating animals have been subjected to great cooling, and reduced to torpor, they can be brought back to life only if the heart is warmed first while they are being revived.

CYCLIC CHANGES IN GLANDULAR ACTIVITY

In view of the great changes in the blood sugar during hibernation, and of the possibility of inducing an artificial hibernation by the administration of insulin, it is not surprising that striking cyclic changes have been found to occur in the insulin-producing gland of hibernatory animals —the islets of Langerhans in the pancreas. The pancreas produces a digestive secretion that is poured into the intestine through the pancreatic duct, but in addition it serves an endocrine function. Certain bunches of cells in its structure do not produce the fluid that is conveyed to the intestine through the duct, but manufacture substances that pass direct into the blood and have an effect on other parts of the body at a distance when carried to them by the blood-stream. These clusters of cells form the islets of Langerhans, and one of their chief functions is the production of insulin, the substance that has such a profound effect upon the metabolism of carbohydrates in the body—if insulin is deficient in quantity the amount of sugar in the blood rises to an abnormal level which may be so great that the animal passes into a diabetic coma that terminates fatally. During hibernation there is a great hypertrophy of the endocrine tissue in the pancreas, the proportion of insulin-producing cells present being much greater than during the summer. But the islets of Langerhans are not made up of uniform cells: there are two kinds, one of which is certainly the type that is chiefly concerned with the

FIG. 2 (*left*). Small clusters of Greater Horseshoe bats hibernating on the roof of a cave. FIG. 3 (*right*). Characteristic position of Lesser Horseshoe bat when hibernating or sleeping; it hangs by its feet, with its delicate wings tightly folded around its body. (*Photo by J. H. D. Hooper.*)

elaboration of insulin, and it is this type particularly that increases in numbers in the hibernating mammal.

The islets of the pancreas are, however, by no means the only endocrine glands that undergo a cyclic change during hibernation. The thyroid gland in the neck, the cortex of the adrenal glands near the kidneys, and the anterior lobe of the pituitary at the base of the brain, all participate in the changes. Of these the anterior pituitary probably takes first place in importance—it has been not inaptly called the "conductor of the endocrine orchestra" because its secretions have such a profound effect on the activities of all the other endocrine glands. The genital glands, which have an endocrine function as well as their primary one of producing gametes, undergo cyclic changes in the hibernators, as in other animals, but although they are dependent upon the activity of the anterior pituitary it is doubtful whether they play any important part in the phenomenon of hibernation.

All these glands are at their lowest phase of activity in the autumn, but during the winter there is a gradual recovery and in the spring they show a great spurt of development that is closely connected with the onset of the breeding season. As far as the thyroid is concerned this burst of activity is short; it is probable that increased temperature during the summer, and the great development of reproductive activity, are responsible for the regression that the gland undergoes from quite early in the spring. The small related glands, the parathyroids, undergo a parallel cyclic series of changes, but it is probable that they do not undergo any marked functional deficiency during winter. The adrenal is a gland of particular interest and many functions; its outer part or cortex contains a zone (the X zone) that is very greatly developed in hibernating mammals during the autumn and winter until the spring, but becomes so reduced as to be practically vestigial during the summer. The central part of the adrenal, the medulla, also undergoes considerable changes during the year, but no marked cyclic activity that can be correlated with hibernation has been identified. The activity of all these glands takes part in the thermo-regulation of the body, but the exact role of each remains yet to be elucidated. It may not be out of place, however, to point out that the "anterior pituitary-thyroid-adrenal axis" is closely concerned with the peculiar 'shock disease' that sometimes afflicts whole populations of animals, particularly those of rodents that periodically build up a peak of numbers far greater than the territory that they inhabit can support.

A last point: it has recently been shown that in some hibernating mammals the rate of clotting of the blood when shed is greatly retarded, and this phenomenon has been interpreted as a special adaptation to hibernation. During hibernation the heart-beat is slow and weak so that the

FIG. 4. The hedgehog, a less regular hibernator than the dormouse, lies up towards the end of the year and remains torpid for about three months. (*Photo by the late A. R. Thompson.*)

circulation-rate of the blood is reduced; it is therefore suggested there is a greater risk of thrombosis—the clotting of the blood in the blood vessels—in hibernating mammals than in active ones. During the active state, on the other hand, the blood must coagulate rapidly in order to prevent fatal loss through a small wound. The cyclic change in the clotting rate of the blood may well be, therefore, of particular importance to the hibernating animal.

Although the experimental removal of the anterior pituitary, with or without the destruction of the cortex of the adrenal glands, together with the injection of insulin, leads to a condition in which the regulation of the temperature is disorganised, and produces a state resembling an artificial hibernation, the role of the different glands remains very obscure—it is not yet known whether many of the changes in them are the causes or the effects of hibernation. Much still remains to be discovered—and the study of the physiology of hibernation and temperature regulation in the warm-blooded animals is not of academic interest only. It is probable that an increased understanding of the processes involved in hibernation will throw much light on the problem of survival in non-hibernating mammals, including man, when they are subjected to extremes of cold and exposure.

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THE EFFECTS OF LOW TEMPERATURE ON ANIMALS

CHAPMAN PINCHER

The idea of keeping a man frozen in ice in a state of suspended animation and reviving him years later has always appealed to the writers of science fiction. No such experiment is ever likely to be attempted, but something surprisingly near it has been achieved. Warm-blooded animals have been frozen almost solid and have then been completely revived—in some cases with no more than trivial injury—by scientists at the National Institute for Medical Research at Mill Hill, London.

The Mill Hill team led by Dr. A. S. Parkes carried out the experiment with hamsters, the small European rodents which are sometimes kept as pets. The hamsters, which normally have a body temperature of about 100°F were painlessly cooled to 59°F by putting them in closed jars in a refrigerator. As they consumed the limited air in the jars they were automatically subjected to a progressive fall in oxygen and a rise in carbon dioxide as well as to the effects of the increasing cold. After this treatment it was found that they could be safely cooled below the normally lethal limit of 59°F by covering them with crushed ice.

The hamsters ceased to breathe when their body temperature dropped to about 40°F, and their heart-beats were no longer detectable when the temperature had fallen by a further four or five degrees. When the animals were cooled below 32°F they started to freeze, and as ice crystals formed in their tissues they became progressively stiffer and were soon like wood to the touch.

Nine of these creatures were successfully revived after being in this frozen state for up to 38 minutes. The scientists achieved this astonishing resuscitation by first warming the hamsters' hearts up rapidly on the principle that, if the whole body is reheated before the blood circulation of the heart itself is working effectively, the tissues will experience severe oxygen shortage and die. A beam of light rays focused on the chest wall was used to achieve the local heating.

Of the many hamsters which survived this rigorous treatment, several lived for long periods and appeared to have made a complete recovery. It is an extraordinary fact that few of these animals showed any signs of frostbite, though in some cases their ears had been frozen to the consistency of cardboard—probably at that stage up to 80% of the water in the ear tissues had crystallised to ice.

At first sight it might be expected that a more gradual process of thawing out the tissues would be less likely to cause injury than such rapid reheating, but recent studies in the treatment of human frostbite have confirmed that in actual fact rapid thawing is more effective.

During the time the hamsters were frozen, life, in the sense that this word is generally used, stopped for them, and was afterwards restarted. Hamsters, of course, are animals which normally hibernate in cold weather and they have a special capacity for withstanding great changes of internal temperature. Yet almost similar freezing experiments have been successfully made with rats, which do not hibernate.

Dr. R. K. Andjus, a young Yugoslav scientist, found that a rat which had been cooled so that its body temperature was only a little above freezing point could be resuscitated if the heart was first warmed by applying a hot spatula or soldering iron to the chest wall before the whole body was heated. It was this discovery which engendered the research at Mill Hill, where Dr. Andjus spent a year demonstrating and refining his methods. In collaboration with Dr. Audrey Smith he was able to improve on the rather primitive technique of applying a hot instrument to the chest and eventually he replaced that method by the use of a beam of light and other more precise and measurable methods.

They found that rats which survive resuscitation for 24 hours usually live indefinitely. Some of them have bred normally after being almost at freezing point for 45 minutes.

Clearly the brain suffers no great injury while it is deprived of oxygen for so long, but it is possible that some subtle damage may occur and 'intelligence tests' on resuscitated rats have yet to be performed.

No larger animals have yet been frozen and revived, but Dr. Juvenelle, who works in Paris, has resuscitated dogs after their body temperature has been lowered to within 22°F of freezing point and maintained at that temperature for many hours.

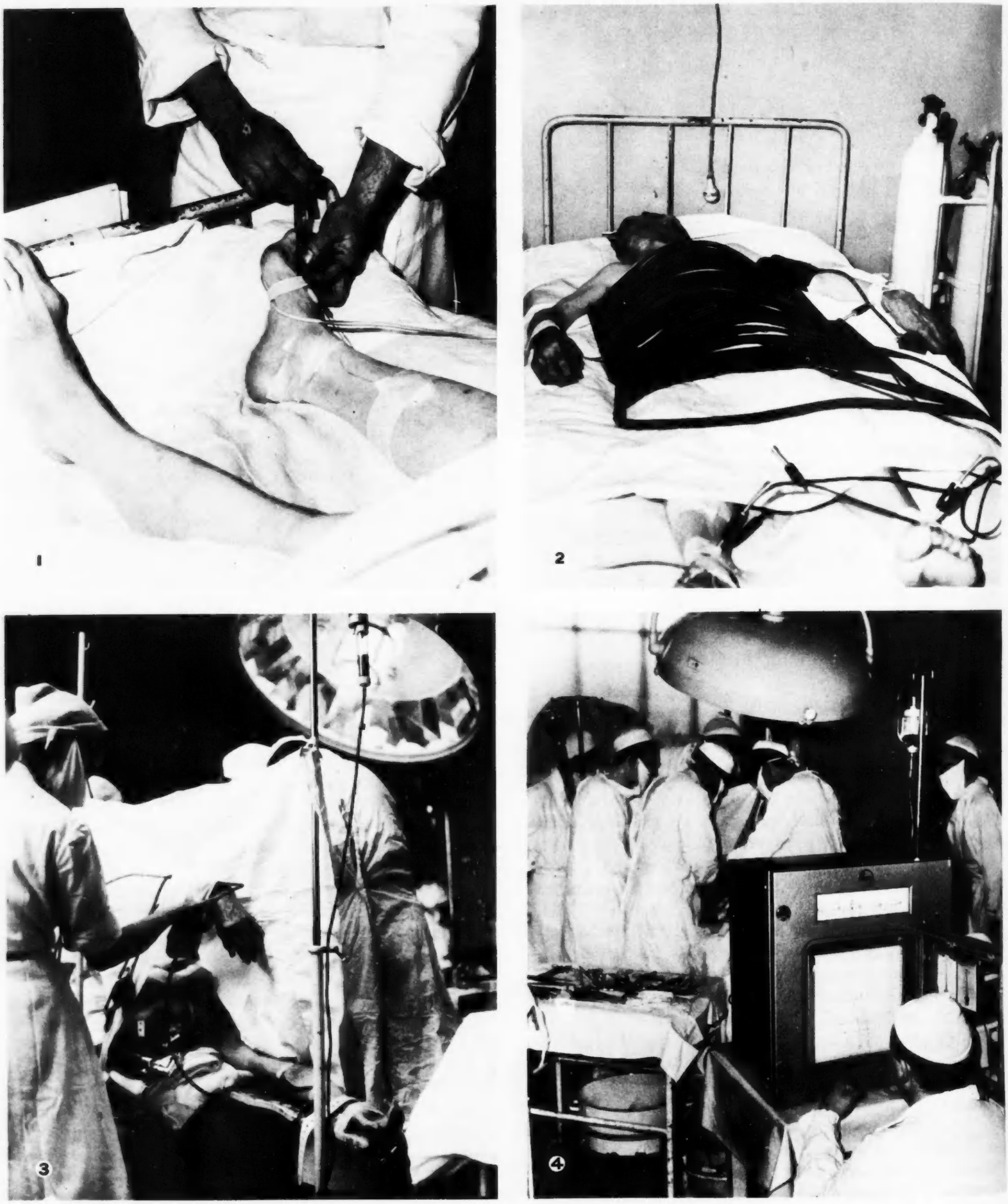
This research on the effects of lowering body temperature was 'fundamental' in the first instance, being performed by scientists who simply wanted to find out what happened and why, but it is expected to have rapid applications to human medicine.

Other experiments in which the body temperature of animals and human beings has been less drastically reduced have already resulted in notable medical advances.

Many operations, especially those on the heart, could be carried out more easily and certainly if there were no blood to obscure the surgeon's view. Bloodless conditions can be achieved locally by clamping off arteries but this always entails some danger because at normal body temperatures the oxygen requirements of the cells are so high that tissues die if deprived of blood for long. When the body temperature is lowered, however, the rate of metabolism, and therefore the oxygen requirement, fall rapidly. So an organ would then be deprived of its blood-flow without injury for a much longer time.

Attempts to reduce human body temperature for medical purposes were made before World War II but with only limited success. During the war Nazi doctors at the Dachau concentration camp made their now infamous experiments in which naked prisoners were forcibly exposed to low temperatures for many hours. They discovered that the human body temperature could be lowered much further than had been thought possible before the victims died, but nothing of medical value emerged from these appalling experiments.

The first large-scale application of the technique of



THE 'HYPOTHERMIA' TECHNIQUE in use at the Vaugirard Hospital in Paris. 1. The 'lytic cocktail', which reduces surgical shock is injected into a blood vessel in the leg. 2. A mixture of alcohol and iced water is circulated through rubber tubes laid across the patient's body: in four hours the body temperature can be brought down from 98·4 to 79°F. (The same procedure is used *after* the operation to keep the temperature down during the shock period.) 3. The surgical operation is performed while the patient is in a state of artificial hibernation. Conventional anaesthesia (with ether or chloroform) is kept ready in case the patient comes to. 4. Instruments record the patient's temperature (it now stands at 33°C, i.e. 91·4°F), as is recorded on the panel at the top, and also the heart rate and blood pressure.

deliberately lowering body temperature was made by the French workers, Laborit and Huguenard, who achieved reduction in body temperature in two ways—by cooling the body surface with ice-bags or rubber tubes containing refrigerated liquid and by lowering metabolism by means of drugs. In the system eventually used on hospital patients a combination of both methods was adopted. The writer has visited the Vaugirard hospital in Paris and has seen the effects of this treatment on patients undergoing severe operations.

The patient is first given a so-called 'lytic cocktail' containing chlorpromazine, phenergan and other drugs, which depress metabolism by acting on the temperature-regulating centre in the brain and also prevent shivering (which is the automatic attempt by the body to increase muscular heat production).

When the patient has become semi-conscious, rubber tubes connected with a refrigerator are wrapped round the body. The patient feels no chill as the iced water circulates through the tubes. The operation is performed when the temperature reaches a level of about 90° F.

The French workers believe that this technique greatly reduces surgical shock, much of which is due to oxygen shortage brought on by the rapid fall in blood pressure that occurs when tissues are severely cut. They claim that in 'poor-risk' operations the treatment halves the death-rate.

In Britain a different method of lowering body temperature for bloodless heart operations has been devised by E. J. Delorme of Edinburgh and D. N. Ross at Guy's Hospital, London, the blood being shunted through refrigerating coils. It has been used successfully by Sir Russell Brock, the heart surgeon, on conditions which would otherwise have been classed as inoperable.

The French workers called their state of reduced body-temperature 'artificial hibernation,' but this name is misleading and the term 'hypothermia' has supplanted it. The latest experiments on animals leave no doubt that genuine hibernation is an entirely different phenomenon. In spite of the ability of rats to withstand the extreme temperature drops already described, scientists are satisfied that there is a profound metabolic difference between an animal that can naturally hibernate and one that is incapable of doing so.

Thus the nerves of a rat cease to conduct below a temperature of 48°F, whereas those of the hamster do not stop working until a temperature of 38°F is reached. In a true hibernating animal all the normal automatic systems of the body are maintained, albeit at a reduced rate, the heart-beat and breathing persisting at temperatures of no more than 9°F above freezing point. The hedgehog displays the spine-stiffening reflex response to being touched even when deep in hibernation. In the non-hibernator, on the other hand, the lungs and heart fail when the temperature falls within about 36°F of freezing point.

There is also the vital difference that the re-warming process is automatic in a hibernating animal. As the marmot—a hare-sized American rodent—returns to consciousness from winter torpidity, its pulse-rate leaps to 200 beats a minute and the fat reserves are burned up so quickly that in two hours its body temperature may be back to its normal figure of 97°F—from a hibernating level of about 38°F. Incidentally, the fat in a hibernating animal like the golden hamster undergoes a change when the creature is exposed to cold so that it remains fluid at low temperatures and is therefore available for metabolism.

Hibernation is usually thought of as an adaptation to winter cold, but it seems more reasonable to regard it as an adaptation to food shortage. Hedgehogs and bats which feed largely on insects would have difficulty in maintaining themselves in winter. Instead of migrating to warmer territory where insects remain plentiful they solve the problem by reducing their energy needs.

This concept is supported by recent American studies on humming-birds which have shown that these enormously energetic creatures virtually hibernate every night. This phenomenon clearly appears to be an adaptation to food shortage and not to cold. Hibernation is not in fact, particularly effective as a means of avoiding exposure to cold. It is revealing to note that animals living well north of the Arctic circle do not hibernate and would presumably die if they attempted to do so.

How these non-hibernators manage to survive extreme cold is now the subject of intensive research, especially in Canada. It is still a mystery how a wading Arctic bird does not get its feet frozen on the ice. The temperature of the webs and legs must be close to zero yet they do not get frostbitten. This capacity could be partly the result of acclimatisation for when an arctic gull which had been kept indoors in a cage escaped on to snow with the thermometer registering 36 degrees of frost its webs froze in less than a minute and part of them became gangrenous.

Recent measurements have shown that down to a certain environment temperature particular to each species, an animal can maintain its body temperature without increasing its metabolism. It simply improves its insulation by raising its fur, puffing out its feathers or by reducing the blood-flow to the skin. For the larger Arctic mammals and birds—the white fox, eskimo dog and polar bear—this critical temperature is certainly below −22°F–54 degrees of frost. It is somewhat higher for the smaller mammals. For naked man—presumably including the Eskimo—it is *plus* 80°F.

Below the critical temperature a mammal has to increase it rate of heat production. This, strangely enough, is not achieved by increased physical activity. The heat produced by exercise is apparently not available for maintaining body temperature in a cold environment. Thus Canadian experiments have shown that a resting Arctic rabbit can withstand short exposure to 117 degrees of frost, but if it has to do work it starts to freeze at a temperature about 72° higher.

British scientists have been rather surprised to find that the common housemouse which is used to domestic warmth can adapt itself to severe cold so that it is able to thrive and breed in cold stores at temperatures below freezing point.

All these studies are changing the whole concept of warm-bloodedness and are leading to a new understanding of the mechanisms whereby body temperature is maintained. As stated at the beginning of this article, the freezing of human beings is never likely to be tried, but if it were physiologists could hardly be more surprised than they have been by some of the discoveries reported here.

There must be more social scientists and more sociological research. This plea was made by Dr. E. D. Adrian, P.R.S. in his presidential address to the British Association. In this article a sociologist discusses the kind of subject matter which comes within the field of sociology, and the methods and utility of sociological research.

WHAT IS SOCIOLOGY?

PAUL HALMOS, Ph.D., Dr. Juris

Sociologists spend much time arguing about the question, "What is sociology?" In no other science is there such a profound concern as to the area which the respective science is to cover. Contrast this with the position of the physicist, the chemist, the biologist, for example, each of whom is content to occupy himself with the hard core of his speciality and does not need to worry much about the definition of his science; it would not occur to these specialists that they might be challenged to prove the relatively autonomous existence of their scientific disciplines. Their material achievements to date and the coherence of the picture which they can present of the various sectors of the universe have consolidated their position as scientists.

It is understandable that the natural scientist is reluctant "to think well of" sociology—I am quoting Dr. E. D. Adrian's words* from his recent presidential address to the British Association—as "it is human nature for the guild of natural scientists to delay admitting a new member till he has paid his dues and satisfied the examiners of his competence in the craft." There are a number of reasons for this reluctance.

In the first place it appears to the natural scientist that sociology has really no subject matter which the other sciences have not tackled or are not already engaged in investigating. According to this view there would be no objection to 'social sciences' in the plural, but no scope would be left to sociology as a scientific discipline of its own right.

The second criticism that comes from scientific circles concerns sociological *method*. It is felt by natural scientists that both the objectivity and the precision of sociological logic falls below the standards of customary scientific requirements: the neatness, quantitative accuracy, and unbiased conclusiveness which the natural scientist expects from his own exertions as well as from those of his colleagues are rarely found in sociological evidence. And finally, the natural scientist is puzzled whether sociological investigations and their findings can be put to any immediate practical use. He suspects the predictive value of sociological generalisations, not only because of the unwieldiness of the all-too-numerous variables which bear on social phenomena, but also—and this is a curious feature—because he is often inclined to consign specific social matters which come within his ken to the realm of indeterminacy or downright mysticism. One cannot help thinking of natural scientists who are devout communicants of some dogmatic group and who, on account of their political or religious commitment wish to remove most social matters from the field of scientific study. They are exasperated with the complexity of social problems and conveniently decide that science ends somewhere half-way through medicine with most of psychology and sociology left beyond the pale. This cultivated 'schizophrenia' of some modern scientific minds is partly responsible for the anti-sociological scepticism among some natural scientists.

Thus to answer the question, "What is sociology?" we must in fact answer three questions, viz. (1) What is the subject matter of sociology? (2) What are its methods? and (3) What are its uses?

(1) There are a large number of entities, processes, and single occurrences in social living which would be left without scientific study if sociology had not been developed to investigate them. Consider, for example, the incidence of divorce in modern western society. No matter what our values, we cannot be indifferent about the question of whether families are stable or disorganised, and consequently we will inevitably inquire into the causes of this phenomenon and will be most certainly interested in its various effects. Who should deal with such a problem as this? The economist? No doubt he could give us valuable information on, say, the relationship between the trade cycle and changes in the divorce rate. He could also compare income levels with the frequency of divorce appearing on each of those levels. He could even make some approximate estimates as to the relationship between the incidence of divorce on the one hand and the type of economic organisation which prevails in a community. But while engaged in these investigations he would have already departed from the subject which we know to be economics; for only one root of his inquiries would be embedded in economics, the other would feed from a different soil for the incidence of divorce is not itself an economic event, even though some doctrinaire thinker might make out that divorce proceedings are exclusively precipitated by economic factors. But if it is not an economic phenomenon, is it perhaps a psychological one? Surely it is, one may contend; the disagreement of marital partners, their embitterment and their eventual break are ultimately accountable in terms of the personalities of the parties involved. In this view, divorce is a psychological problem with exclusively psychological causes and effects. Now we have already seen that certain economic circumstances are by no means irrelevant to the incidence of divorce; furthermore, there are several other features in social life which function as variables at least partially independent from both economics and psychology. Religious affiliation of the partners to the marriage is one of these; a 'crisis situation' such as a war is another. Hence a purely psychological study of divorce would be just as incomplete as a purely economic one. At the same time we cannot deny

* This quotation comes from p. 354 of the September issue of DISCOVERY in which the whole of Dr. Adrian's B.A. presidential address was printed.

that a systematic and comprehensive study of a social phenomenon like divorce is possible; such studies have in fact been carried out. Reading the results of work of this nature, we find that a careful attempt is made to assess not only the economic and psychological factors which enter into the causation of divorce but also all other determinants such as the legal, moral, religious, and demographical factors—possibly even geographical factors. The assessment is made through a dovetailing of the contributions made by each and all of these, and eventually rules, generalisations, and laws are arrived at as a result of this work. It is at this point that the existence of a new science becomes apparent for the first time. After all, these laws and generalisations are neither psychological nor economic, legal, moral, geographical or medical; they are *social* generalisations. Durkheim, one of the founders of modern sociology, wrote a treatise on *Suicide* which has served as a model of this type of inquiry to students of sociology. Today we have a large number of monographs treating single social phenomena in much the same manner except, of course, the contributions from psychology, economics and the other social sciences are now on a more advanced level than they were in Durkheim's time. I have selected divorce and suicide for illustration because many of the monographic studies are inspired by the need to understand specific social problems of a distressing nature. There are, of course, similar studies on standard social phenomena such as co-operation, competition, occupational selection, industrial relations, educational opportunities, and many others.

PROGRESS TOWARDS A UNIFIED CONCEPTUAL SYSTEM

It would be a mistake to think that sociology consists merely in the design of monographic studies of this kind. If it were so, sociology would not amount to more than a collection of disconnected field studies. For some time this was indeed the case. The only overall systems which comprised these disconnected pieces of research were inspired by political bias or religious dogma. The resulting ideologies have not infrequently moulded factual findings to suit preconceived systems of social thought. Needless to say the results were hardly scientific. Today there are signs that a systematic ordering of these partial studies may become possible. It would be premature to say that sociologists are anywhere near to a universal agreement on a scientific system which would incorporate all sociological conclusions. Yet already some interesting progress has been made in this direction. Between the time Max Weber set out his ideas on this subject some thirty-five years ago (cf. *The Theory of Social and Economic Organisation*, London, 1947), and the publication of *Toward a General Theory of Action* by Talcott Parsons and Edward Shils (Harvard University Press, 1951), there have been several honest attempts at a sociological synthesis. It is not very easy to interpret the work of synthesis carried out by these sociologists to those who are unfamiliar with the problems of sociological theory. Suffice it to say that the main task of these sociologists has been the development of a uniform conceptual system, a kind of sociological *lingua franca*.

With the help of a uniform conceptual scheme it may become possible to formulate sociological generalisations which would be applicable to any 'monographic' field within sociology as a whole. The economy of thought which the success of a conceptual synthesis may bring would be of great value to the progress of sociology though it is unlikely that sociological theory will ever assume the same position towards applied sociology as that which obtains in the case of pure mathematics towards applied mathematics. Nevertheless the pursuit of this ideal is legitimate until it is definitely discredited. Unfortunately the systems so far developed lack clarity of design and suffer from an involved style—sometimes scandalously involved style—of those who expound them. Notwithstanding these shortcomings, here we have an unmistakably sociological field of study which is bound to occupy a central position in this science as time goes on.

STUDIES OF SOCIAL GROUPS

Even before the appearance of these projects there were other discoveries of social topics *par excellence* which sociologists were obliged to carve out for their own specialist attention. Two of these are particularly interesting, for apart from their other merits there seemed to be a possibility of sociological synthesis through both of them. The first of these is the study of the so-called 'small groups'. Since the pioneer work of the German sociologist Georg Simmel (cf. English translation, *The Sociology of Georg Simmel*, Free Press, 1950) and the American sociologist Charles Horton Cooley (*Social Organisation*, New York, 1909), research has been going on into the behaviour of the so-called 'face-to-face groups', that is of groups in which each member is in frequent face-to-face relationship with all the other members of the group. The laws that determine the functioning of these groups seem to have a specifically sociological nature. The psychologist cannot claim this field for himself for there are many factors here which are external to psychology. To illustrate, one may know of the psychological processes of *A* and those of *B*, but when *A* and *B* are together things happen between them which are the products of this twosome—or *dyad*, as it is called—and not that of the psychologies of either *A* or *B* separately. Needless to say, if *C* enters, the permutation of possible relationships increases and new phenomena appear. One valuable extension of modern small-group study is that introduced by J. L. Moreno who discovered a technique, known as 'sociometry', by which the inner structure of a small group can be mapped out. With the help of his sociometric tests, it is now possible to find out whether the group contains isolated, rejected, or popular ('star') members, and whether there are subgroups, cliques, pairs and so on within it. The principal areas in which the study of small groups has great practical importance are: clinical therapeutic groups, industrial communities, all kinds of committees, teams, staffs and so on.

Then there is the second vast subject-complex called 'culture'. It is now generally agreed that the sum total of our heritage in faith, knowledge and possessions—i.e. culture in the broadest sense—is a quality of society as a whole and not a function of one of its part-processes such as economics, psychology or this or that partial component

of the social process as a whole. Thus the vicissitudes of culture and the topography of its inner structure cannot be studied effectively through an exclusively economic, psychological or historical approach. Once again a sociological synthesis is necessary. Finally there are the larger 'monographic' subjects of race, class, leadership, roles, attitudes, to mention only a few and the processes of competition, co-operation, conflict and others, neither of which can be understood thoroughly when treated by one specific social science alone. If we remember, for instance, that competition is equally possible between lovers, business rivals and nation states we may more readily accept this claim. If I were asked to define sociology, I should accept the formula according to which sociology is a science of the structure and function of human relationships. And here lies one of the secrets of our difficulties: whereas, physics, chemistry, biology and so on, deal with a tangible sector of the universe, or at any rate, with a sector most of which is tangible—even psychology treats an identifiable individual who at least persists in being, who is visible and can give an account of himself—sociology concerns itself with *relationships* which are much more ephemeral and far less tangible. *Yet the transitoriness of a phenomenon does not make that phenomenon non-existent.* The subject matter of sociology is indeed very much a reality.

METHODS OF SOCIOLOGICAL RESEARCH

(2) The elusiveness of the subject does not make the methods of studying it any easier. It is only natural that sociologists have always tried to apply the scientific methods of observation which proved so fruitful in the so-called exact sciences. The first man to use the term 'sociology', Auguste Comte (1798–1857), believed that the application of the positive methods of science to the life of human societies would eventually lead to a beneficial control over the hazards, destructive conflicts, and miseries of social existence. Sociologists today are still inspired by Comte's expectations, but they have learnt by now that scientific methods of research in sociology cannot be simple replicas of those employed in the other sciences. The research tools have not only to be redesigned but new ones have to be invented. Some of the methodological problems of sociology are the same as those of psychology.

Take, for example, the problem of observation. In both of these sciences it is most difficult to neutralise the observer's personal bias towards what he is engaged in observing. The truth of the matter is that unless proved otherwise we must always reckon with distortion coming from this quarter. Nevertheless a constant cultivation of reserve and healthy scepticism can save us from much self-deception. It is one thing to insist that we must be ever on our guard, and another to throw in one's hand and say that it is impossible to verify sociological generalisations. This is what I meant by saying that the natural scientist's sweeping scepticism in the face of sociological aspirations can lead to one outcome only—that, of all people, he will prefer to leave the solution of social problems to chance or to the ministrations of dogmatically committed people. It is in this spirit that the various research techniques of sociology should be assessed by the natural scientist who, whilst perfectly justified in questioning the merits of a particular sociological method, would be inconsistent in repudiating the scientific status of sociology itself.

Of the current techniques of sociological research I will mention some which play a prominent part in modern investigation, such as participant observation, mass-observation, interview techniques, questionnaires and other tests, the use of demographic materials and other recorded statistical data, and sociological experiments. A few words on each of these may throw some light on the sociologist's work and its difficulties. In *participant observation* the investigator has to enter the group which he is to study as a normal member of that group. Whether he will reveal his true identity or not will vary according to the group's anticipated attitude towards being observed. In a project of this kind the investigator must assume a dual role: he must retain the impartiality of an outside observer as well as identify himself to the maximum degree with those whom he observes. Indeed an exacting task the technicalities of which have not yet been worked out.

Since Le Play went to live with the families whose home-budgets he was investigating (*Les Ouvriers Européens*, 1855) we find sociologists taking up work in hospitals, joining trade union branch meetings, getting themselves hired as miners, waiters, garage mechanics, and the like in order 'to get under the skin' of the social situation and to observe its workings from the inside. This is no 'slumming' or mere collecting of impressions. The material is to be collected according to a prearranged plan which has been inspired by preliminary hypotheses. Nels Anderson who became a tramp to write his book *The Hobo* is not necessarily the best example of this sort of approach. But the authors of the better known studies of *Middletown* and *Yankee City* also relied on participant observation at many stages of their inquiry with results of a more significant kind. In these ambitious projects of study the social life of whole towns comes under review and a good deal of the information derives from sources treated by other methods as well.

Mass Observation using a national panel of informants as well as full-time observers does not differ essentially in its techniques from those mentioned before.

The method of interviewing was inherited by sociology from social work, from clinical and psychological practice. Here the objects of observation are not primarily social relationships but the individuals taking part in them, and generalisations relating to social relationships are inferred from the multiplicity of interviews obtained. Interviewing techniques range from the intensive and protracted clinical interviews to the few minutes' street corner questions to which answers may be taken down as simple 'YES', 'NO', or 'DON'T KNOW'. One must discriminate between interviewing which aims at obtaining information on what people *think they think* from the kind of interviewing which tries to establish what people *really think*. The former cannot claim to accomplish more than a picture of overt public opinion, of ostentatious attitudes, or of simple opinions. The one-sidedness of this method was brought home to an American investigator who desired to find out about people's attitudes to Sunday baseball. One answer he received was, "Everybody is for it but public opinion is against it." It is, of course, a mistake to think that people's

ostentatious opinions are not significant social facts worthy of investigation; they are, and the mechanisms which underlie them are of considerable interest to the sociologist.

THE USE OF QUESTIONNAIRES

Interviewing which aims at discovering what people really think is a much more arduous business. In the light of modern psychological interpretations and findings it seems that no one can be absolutely certain of the true nature of his innermost motives. Short of an extensive psychoanalytical investigation very little of unconscious motivation can be ascertained in other ways and particularly in brief, desultory interviews. And when sociological investigators make use of personality tests which were originally devised for clinical purposes they simply take over psychological tools: these are not sociological instruments of research. Perhaps the most valuable of the psychological tests are the so-called projection tests. One of these, the Thermatic Apperception Tests (T.A.T.), consists of twenty picture cards displaying ordinary life-situations as well as some surrealistic fantasies. The subject is asked to make up a story about each picture and the tester having recorded the products of the subject's imagination proceeds to analyse them according to a carefully prepared and checked code. The basis of this technique is the psychological doctrine that all human fiction contains salient elements of its creator's personality which the creator *projects* into his creation. The advantage of this test is that the subject's sophistication, reserve and self-defence are of no avail to him and so long as he co-operates he is bound to reveal some traits of his fundamental nature. Meanwhile in the *questionnaire form of personality assessment* as well as in all other types of questionnaires the subject is clearly in a position to give answers which he thinks would shelter or enhance his prestige. A great deal depends on whether the questionnaires are administered in a way that the subjects remain anonymous or that they bear the names of the respondents when they are handed in. There is no doubt that anonymity reduces the vitiating influence of prestige though it does not altogether eliminate this factor. Alas, there are great difficulties in securing the genuine co-operation of large numbers of people in those areas where research is badly needed. This is a crucial impediment of all sociological research, but in respect of questionnaires I have found resistance most articulate. Filling up questionnaires is reminiscent of filling up official forms, and the negative attitude to authority in the latter case is prone to reappear as sceptical, sometimes frivolous, and sometimes even hostile attitude towards the sociological researcher. The factor of intelligence further adds to your troubles. People may not understand the simplest of questions and even when they do they are often inexperienced in assessing what they feel or think and in expressing what they have assessed. There is little to be said about the way in which the statistical returns of public records offices can be exploited for sociological study. The material is, of course, extremely valuable, but it could hardly be sufficient to supplant the specially collected information of field studies. The statutory censuses and other surveys reveal only the barest outline of social life and could not serve as an adequate body of factual information for the comprehensive study of social structure and function.

Finally, I should like to comment on the deliberately staged sociological experiment. This method is very much in its infancy, and its progress is substantially hampered by ethical, religious, and political considerations. Yet there are some highly suggestive instances of achievement in this sector of research which deserve mention. In one investigation dealing with white-negro relations in the United States the anti-negro attitude tests administered to a group of white college students were followed up by arranging for them intimate contacts and social gatherings in the homes of prominent negro intellectuals and generally by exposing them to some favourable aspects of negro life with which they had not been familiar. After these experimentally created opportunities a second attitude test was administered to assess the impact made by these new experiences on the group of white students. Housing schemes have provided another occasion for sociological experiment. Personality tests and family studies carried out on slum-dwellers, before rehousing and after, conformed at least in some respects with experiments which take place under controlled conditions in a physical or chemical laboratory. Experiments in propaganda on fictional issues, experiments in small-group management, experiments in industrial management, and in several other fields of sociology show that this method is one of the most promising in contemporary sociology.

THE APPLICATION OF SOCIOLOGICAL KNOWLEDGE

(3) After this brief outline of the subject matter and methods of sociology, one may inquire whether the lessons learnt from the endeavours of sociologists are of any great value to those who are called upon to manage social groups of all sizes? Whether sociological knowledge appreciably increases the average citizen's understanding of his social relationships and thereby assists him in adjusting himself to these relationships? In short, one may ask, what is the use of sociology? People who ask such questions as this should be clear about the precise meaning of the word 'use'. It is obvious that its meaning is not the same in "What is the use of history?" as it is in "What is the use of the internal combustion engine?"

Those who are apprehensive of the sociologist's claim for attention are often inclined to demand a demonstration of this science's utility in the latter sense. It may be possible to offer some satisfaction even to these people by selecting a few examples in which the immediate usefulness of sociological 'intelligence' has been amply proved. In a recent study *The Changing Culture of a Factory* by Elliot Jaques (Tavistock Publications, 1951), we find that the psychological and social forces which influence and to a large extent determine morale, productivity and human relations in industry are amenable to a certain important measure of control, provided that the industrial situation is approached in the dispassionate and scientific manner of the sociologist's technique. Though the author was not preoccupied with productivity issues and concentrated on questions of morale as well as of smooth consultative and executive administration, there is no doubt that his findings

have a most significant bearing on productivity. This is the sort of sociological research the immediate usefulness of which cannot escape the notice of anyone who consults the report on its proceedings. Those interested in the elimination of wasteful hostilities and costly obstinacies from industrial practice may inquire why these research techniques are not more widely known, and practised and why their lessons are not turned to immediate profit by the generous extension of sociological education?

In another sociological study—on family life and child care—evidence was obtained as to the relationship between the loneliness of mothers on the one hand and family friction as well as faulty child-care on the other. This finding resulted in concentrating social work on assisting the socially isolated mothers in their social activities, thereby alleviating family tensions and improving parent-child relationships in some of the selected cases. Now apart from the palpable benefits promptly secured in this isolated venture it is manifest that the social work techniques reported can be repeated and refined elsewhere and, what is more important, the lessons obtained may beneficially modify enterprises as widely different as town-planning, further education and child guidance clinic practice. For, in all these, provisions could be made to direct some aspect of the services towards the prevention and therapy of loneliness in a mass society. Further we find that, for instance, studies in the sociology of education furnish pointers to the educational planner and legislator, that investigations into the social framework of delinquent behaviour powerfully inhibit the rule of emotion and doctrine in judicial and administrative action, that research into the causes of racial tension, of prejudice, of intolerance, of conflict steers the activities of private and statutory agencies towards practical and scientifically tested measures.

It would be a disservice to sociologists to claim more significance and greater achievements for them than the state of their science would warrant. Sociology is still in an early stage of its development; it still lacks an integrated theoretical structure, sufficiently refined and reliable methods, and, let us face it, adequate funds as well as public support to make itself more palpably 'useful'. Yet sociological description and analysis has become an indispensable condition of understanding social phenomena rationally. Scientists today must face this; we cannot do without the sociological approach unless they prefer to submit to dogmatic and ideological solutions of our contemporary problems. Sociology does not claim to reveal the whole truth about the social condition of man, but it can warn us off some of the lies with which our world is so well stocked.

JUBILEE OF THE FLEMING VALVE

In connexion with the celebration of the jubilee of the invention of the thermionic valve by Sir Ambrose Fleming on November 16, 1904, a conversazione is being held in the Electrical Engineering Department of University College, London, on November 16–18. A plaque commemorating the occasion will be unveiled by the Lord President of the Council. Exhibits and documents relating to Sir Ambrose Fleming's work while Professor of Electrical Engineering at the College will be on view.

* * *

There are very few major inventions that do not give rise to controversy or counter-claims, and the invention of the 'oscillation valve' by Sir Ambrose Fleming was no exception. By the greatest ill-fortune he did not think of inserting the all-important third electrode in the valve which gives it amplifying properties, and when Lee de Forest produced his three-electrode 'audion' two years after the Fleming patent had been accepted the trouble began.

The priority of the Fleming valve patent was fought for by the Marconi Company and the Radio Corporation of America through court after court in the U.S.A., and the litigation only ceased when the patent expired during the first World War. The claim for an extension was refused on the grounds that the Marconi Company (the assignees of the patent) had recouped themselves sufficiently. Fleming like so many other inventors, did not make a fortune out of his pioneer work.

This was not his only grievance, as he bitterly resented any attempt to deprive him of association with the original valve, and, it must be said, of association with later developments of his original valve. To him all valves were Fleming valves, and he objected to any other nomenclature. Speaking at the Physical Society's Exhibition about twenty years ago he said: "There has been a considerable amount of misapplied ingenuity in trying to replace my simple word 'valve' by other meaningless terms . . . Others have, I regret to see, employed the term 'diode'. I see no advantage in making use of scientific gibberish of this kind, when simple English dictionary words are available."

Unfortunately the development of scientific nomenclature did not respect his wishes, and the convenient and logical words 'diode', 'triode' and the other odes (coined by Prof. W. H. Eccles) have now taken root firmly. It is a slight compensation that the word 'valve' is dying very hard and it will be a long time before it disappears altogether in favour of the inelegant 'toob'.

One other important and little-known contribution was made by Fleming to electrical terminology. He first used the word 'power-factor' to denote the ratio of true and apparent power in an alternating current circuit. His work in electrical engineering ranged from accurate measurements of the ohm to transformer design, and the Fleming Standard Lamp was used as a standard of illumination for many years. For all these things Fleming deserves to be remembered, and there is no doubt that those who celebrate his jubilee this month will also recall his ability as a teacher and writer, and the wide range of scientific subjects to which he brought fresh ideas

FUNGI THAT THRIVE ON WOOD

B. BARNES, D.Sc., Ph.D., F.L.S.

The woody materials on which many fungi live are diverse; they differ in kind, size, position and condition. The size can range from large trunks, stumps and branches to thin twigs: these may be high in the air, close to the ground, or more or less buried in the ground, and it is obvious that the position will influence humidity. The wood may be living or dead, and then recently dead and still sound, or long dead and then more or less decayed. The fungi which live on wood—the *lignicolous* fungi as they are called—have a mycelium which spreads in wood, and a fructification which forms on the surface of the wood and sheds its spores into the air. Some of these fungi are very large, with fructifications measuring more than a foot across and weighing many pounds. The giants merge by gradations in size with species having fructifications hardly larger than a pin-head, and with the even smaller moulds which cannot be seen without a lens. In this article I shall not attempt to describe the small moulds, or those wood-rotting fungi which occur chiefly on worked wood buildings and in ships.

Most of the wood-inhabiting fungi are Basidiomycetes, a few are Ascomycetes.

These fungi are remarkable for their capacity to use wood as a source of nutriment, a capacity exhibited by few other organisms; the enzymes necessary for the digestion of wood into soluble substances utilisable as food are not widely distributed. Attempts to grow the lignicolous fungi to maturity in artificial culture often fail, and this failure may well be because the relatively simple media commonly used do not allow of the efficient working of the enzyme-systems of these fungi, those systems being so adjusted to the task of decomposing a complicated substratum that they succeed only on a substance as complex as wood.

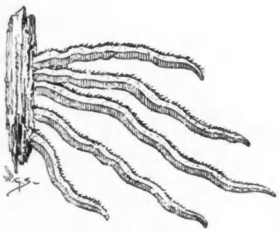
Almost any garden in which logs and sticks are lying in the open, and any piece of woodland—especially mixed woodland—may be expected to show, in late autumn, some of the commoner lignicolous fungi. Old stumps and logs, especially if of oak, will be decorated with groups of the small, thin, horizontal brackets of the common stump-flap (*Polystictus versicolor*), which is easily recognised by the banding of the upper surface in browns, grey-greens and dull purples, and by the tiny pores crowded on the creamy lower surface. This fungus is not limited to oak. It is a powerful rotter of many kinds of wood lying in damp places.

Stumps and logs which have not long been cut may bear the thin brackets of *Stereum hirsutum*, an inch or more across, their upper surfaces covered with a greyish felt, their lower surfaces yellow, and without pores or prominent ridges. The brackets may be seen also on the vertical sides of dead boughs still on the tree, as well as yellowish crusts of the fungus on the lower surfaces of the same boughs, which may carry also fructifications of other closely related species of *Stereum*. In *Stereum*, as in bracket-fungi in general, the spores are formed on the lower surface of the fructification. This ensures that the ripe spores fall into the air below, a necessary preliminary to their effective dispersal by air currents. The orientation of the fruit body, with its fertile lower surface exposed and turned downwards, depends on the posture of the support to which the fungus is attached, and this determines whether brackets or crusts are formed.

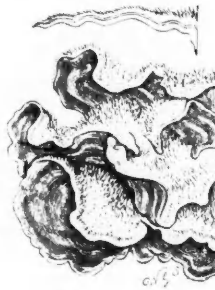
In places where *S. hirsutum* is common, whether on oak or other woods, yellow, slimy patches may be noted on the brackets. These patches are the plasmodia of the 'slime-fungus' *Badhamia utricularis*,* a most interesting organism which is very easily grown on pieces of *Stereum* placed under a bell-jar or other suitable glass cover.

The purplish brackets or crusts of *S. purpureum*, which bleach when they dry in strong light, are very common on dead pieces of poplar; they are not to be confused with the rather similarly coloured brackets of *Polystictus abietinus* which are not uncommon on rotting trunks and branches of coniferous trees, for the presence of pores on the under-surface of the *Polystictus* at once distinguishes the two fungi. *Stereum purpureum* is the cause of silver leaf in plums and cherries, and it is a slow but potent killer of *Laburnum* and less often of almond. The mycelium blocks the water-channels in the young wood, but it does not enter the leaves. These dry as the water supply is cut off, air enters the leaf because the epidermal cells

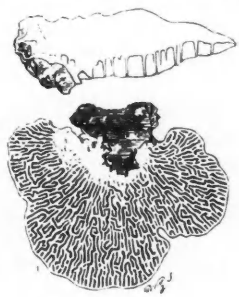
* An excellent account of *Badhamia* by A. Lister is to be found in Vol. II, of the *Annals of Botany* (1888); the experiments which Lister describes there are easily repeated, with the simplest apparatus.



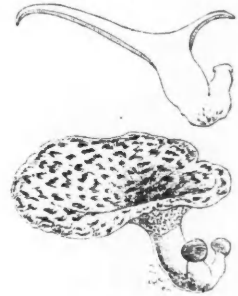
Section of *Polystictus versicolor* (half natl. size)



Stereum hirsutum (natl. size)



Daedalea quercina (× ¼)



Polyporus squamosus (× ⅐)

become loose as they dry, and so the silvery sheen is caused. The fungus forms its brackets only on dead wood.

The coral-spot fungus (*Nectria*) is perhaps the commonest of the lignicolous fungi. In the later part of the year, its small pink fructifications abound on dead sticks; they are especially common on those of sycamore and horse-chestnut, but the fungus will appear on almost any kind of thin branch. Commonly the spots, a little larger than a pin-head, are pink and somewhat rough; less often the spots are smoother and redder, these being usually formed not far from ground-level. The pink spots are the imperfect stage* of the fungus and have been called *Tubercularia vulgaris*, the redder spots are the perfect stage in which ascospores are formed. The two stages were once regarded as separate species and the latter was called *Nectria cinnabarina*, which is the valid name of the fungus. The coral-spot lives mainly on dead wood, the spores settling on stubs and germinating there. Sometimes, especially in the currant, the mycelium grows from a stub into a living branch, where it blocks the water supply, and dries out and kills the branch above the stub; the spots form only on dead branches.

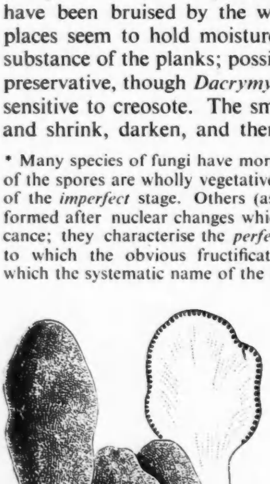
Wooden fences, particularly when made of deal, often bear, not far above ground-level, again where the supply of moisture is good, a rich crop of small orange-red or yellow gelatinous pustules. These may be washed away by heavy rain, and they seem to disappear quickly when the weather becomes dry. They are the fructifications of the basidiomycete *Dacrymyces deliquescens*. The fungus is common on open wooden platforms of railway stations, fruiting in the spaces between the planks, particularly on edges which have been bruised by the wheels of hand-trucks. Such places seem to hold moisture better than does the solid substance of the planks; possibly they are lacking in wood preservative, though *Dacrymyces* does not seem to be very sensitive to creosote. The small pustules dry out quickly and shrink, darken, and then are difficult to see on the wood; they swell and colour up very quickly when they are wetted. The orange-red spots are the imperfect stage; basidiospores are to be found in the yellow spots. *Dacrymyces* is sometimes abundant on chips of pine lying around the stump of a recently felled tree, and it may be found, though less often, on similar chips of oak.

Stumps which have been cut off a foot or so above ground-level may carry fungal fructifications for a number of years, until they become so rotten that they can be colonised by miscellaneous herbage. Such stumps of oak often bear large numbers of the brackets of *Daedalea quercina*, easily recognised by their furrowed, grey-zoned upper surface, and even more by the labyrinthine pattern made by the irregular pores on the lower surface. The name *Daedalea* refers back to *Daedalus*, the architect of the labyrinth said to have been built by Minos in Crete, a story probably developed from the recollections of the drainage system of the palace taken back to Greece by the half-savage invaders who destroyed Knossos; they are hardly likely to have understood a drainage system or to have troubled their heads about sewage disposal.

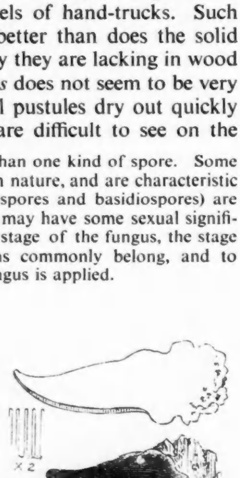
THE LARGE BRACKET-FUNGI

Oak stumps, as well as massive logs left on the ground, often bear crops of the enormous fructifications of the dryad's saddle (*Polyporus squamosus*). These are vaguely stalked brackets, formed somewhat like an imperfect funnel, and are easily recognised by their size, and especially by the small, feathery, brownish patches which speckle the upper surfaces. The dryad's saddle is cheesy in texture and decays quickly. It is more often seen in summer (if wet) and early autumn, and seldom lasts into the colder part of the year. It is regrettable that this handsome fungus is so often mutilated by passers-by. More resistant than the dryad's saddle, and common wherever birch abounds, are the robust, stalkless brackets of the razor-strop fungus (*P. betulinus*); it seems to be especially abundant where these trees grow on wet ground. *P. betulinus* is a parasite, entering the sapwood through a wound, and soon killing the tree. The trunks usually break off at eight to ten feet above ground-level, but the fungus may persist on the dead trunk for some time. Slices of the brackets, usually after impregnation with a fine-grained abrasive, were formerly used as

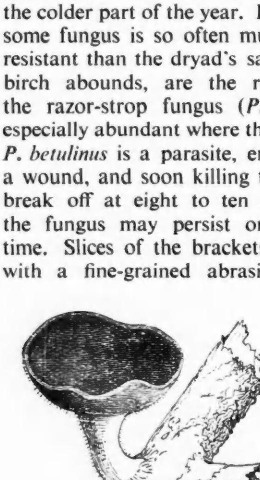
* Many species of fungi have more than one kind of spore. Some of the spores are wholly vegetative in nature, and are characteristic of the *imperfect* stage. Others (ascospores and basidiospores) are formed after nuclear changes which may have some sexual significance; they characterise the *perfect* stage of the fungus, the stage to which the obvious fructifications commonly belong, and to which the systematic name of the fungus is applied.



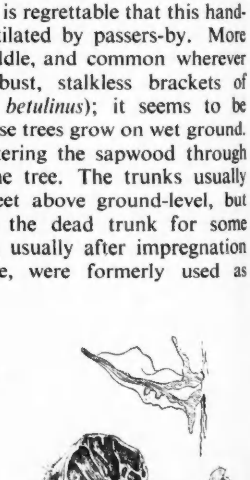
Xylaria polymorpha (natl. size)



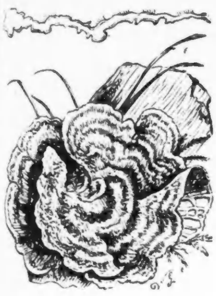
Fistulina hepatica (beef-steak fungus, × ⅓)



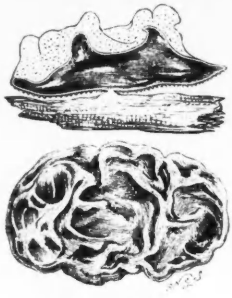
Sarcoscypha coccinea (natl. size)



Hirneola auricula-judae (Jew's Ear fungus, × ⅓)

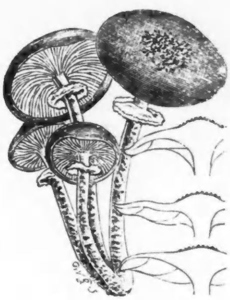


Auricularia mesenterica (one-third natl. size)



Exidia glandulosa (natl. size)

Hypholoma fasciculare (one-quarter natl. size)



Armillaria mellea (one-third natl. size)

razor-strops, and corn pads and tinder were also prepared from the dried brackets. There are many other species of *Polyporus*. The large and conspicuous *P. sulphureus*, bright orange-red to yellow, is frequent on trunks of various trees, usually rather high up. It fruits year after year in the same place, but the heart-rot it causes eventually brings the large branches down. *P. pomaceus* is not rare on old apple and cherry trees.

Sometimes, close to a tree stump, a toadstool may be found, with symmetrical caps and gills on its lower face and with upper surfaces speckled rather like those of the dryad's saddle: the gills and the shape, however, distinguish it clearly. It is a *Pholiota*.

The stumps of various kinds of trees may bear, often rather close to ground-level, large brackets with shiny upper surfaces appearing as if they were varnished, though the brackets are often ridged and furrowed, and of tough texture. When these are cut across, several layers of tubes can be seen, these layers having been formed by successive spurts of growth, one or more in a year, or maybe sometimes at longer intervals. These large shiny brackets belong to *Ganoderma*, of which there are several species, *G. applanatum* being common on beech. Even larger, hoof-shaped brackets may be found at the bases of old elm trees; they are multi-layered, but not shiny above. They belong to *Fomes ulmarius*, which causes a heart-rot of the elm, leading to eventual hollowness of the trunk, though the sapwood may live on for many years. The mycelium of this and of other fungi which decompose the heartwood of trees enters through a wound or sometimes from a damaged root. The rot usually proceeds rather slowly, and is not infrequently accompanied by the formation in the wood of a darkly stained zone which is exposed as the trunk becomes hollow. It then looks as if the inside of the trunk has been charred, a deceptive appearance which has misled many casual observers. *F. igniarius* is one of the fungi which causes hollowing of the trunk of willows. The fruit bodies of it, and of its relative, *F. fomentarius*, a rather rare species in this country, have been used, like those of *Polyporus betulinus*, for the preparation of corn pads, tinder and similar items.

A common, but relatively inconspicuous inhabitant of the stumps of various kinds of trees is the candle-snuff fungus (*Xylaria hypoxylon*), which is not infrequent on elm. This fungus is an ascomycete. Early in the autumn, the antler-like fructifications become whitened at the ends of their branches which are covered with the spores of the imperfect stage; later, when these spores have been shed, the 'antler' turns black, and it is then found to contain the perithecia in which the ascospores are formed. A related species, which does not seem to be so common, has a fruit body which is some two to three inches tall and is shaped like a clumsy club. This is *X. polymorpha*, a species associated particularly with beech; it has been found on stumps of the cherry laurel in suburban gardens. Stumps of beech, and perhaps more often of ash, may be studded with the rounded black fructifications, sometimes nearly as large as small oranges, of *Daldinia concentrica*; these show stratification when they are cut open, but this is not an indication of annual increments of growth. The much smaller, related fungus called *Hypoxylon* forms its fruits on beech, and sometimes this grows in enormous numbers on the stems of gorse which have been burnt over. The fruits are commonly of the size and shape of half a pea, and are reddish to brownish in colour. Both *Daldinia* and *Hypoxylon* are ascomycetes.

Oak trees with the uppermost branches standing dead and bare above the rest of the tree—stag-headed oaks—are often seen. A search at the base of such a tree may show a cavity in the trunk just above ground-level, and in that cavity there may be one or more specimens of the very large, soft brackets of the beef-steak fungus (*Fistulina hepatica*). When cut, these brackets exude a somewhat bloody juice, a circumstance which accounts for the popular name of the fungus, and which maybe has given to *Fistulina* a somewhat inflated reputation as an esculent. It has some merit as a food, but in taste and texture it falls far behind the mushroom, and some of the good edible toadstools. The effect of the fungus on the wood of the oak is of more interest. Long before the wood has rotted and lost its mechanical strength, it has been stained a fine brown, and the colour spreads for some distance up the trunk. The stained wood is the brown oak or lion oak, which is justly esteemed for cabinet work. Another common fungus on the oak stains the wood a vivid green, but the stained patches are small, so that the wood can be used only for making small objects or for inlays. Green oak is common enough, but the tiny, green, cup-shaped fructifications of the fungus responsible for this effect—*Chlorosplenium aeruginosum*—are seldom seen. This fungus is an ascomycete, as is *Sarcoscypha coccinea*, perhaps the most beautiful of our fungi. This species lives on twigs lying in moss, and the stalked cups seldom form until early spring,

(*Left*) *Pholiota squarrosa*: this large toadstool is sometimes very conspicuous on stumps, particularly of ash and apple. It is yellowish in colour, with brownish flecks.

(*Right*) *Xylaria hypoxylon*, the candle-snuff fungus.

one to several on a twig. They may be up to an inch tall and an inch in diameter, but they are often smaller than this. The stalk and the outside of the cup are clothed in a delicate white felt, which brings out the beauty of the carmine inner surface of the cup. This fungus well merits the popular name of fairies' bath. It has also been called Jew's ear and Judas's ear, names better applied to *Hirneola auricula-judae*, a basidiomycete, which is common on the stems of elder. The ribbed under-surface of its hooded fructification vaguely recalls the pattern of the human ear, and the name connects with the legend that Judas Iscariot hanged himself on an elder tree; his ears appear in the fructifications. *Hirneola* has a common relative, *Auricularia mesenterica*, to be found in large patches on the stumps of various kinds of trees. It is soft and gelatinous when fresh, horny when dry. The gelatinous texture distinguishes it at once from *Stereum purpureum*, which it may resemble in colour, the absence of pores from the lower surface distinguishes it from *Polystictus versicolor*, with which its zoned upper surface might confuse it, and the texture, with the irregular shape of the fruit bodies distinguish it from *Bulgaria polymorpha*, a very common fungus on recently cut oak, which produces large black, regular cups of remarkably rubbery consistency.

Thin twigs seldom support fungi of any size, but there are two fairly common species which may well appear in late autumn. One, *Exidia recisa* is common on branches of willow, forming brownish-yellow soft masses; it has a relative, the greyish-black *E. glandulosa*—the witches' butter, with a preference for the branches of lime. *Tremella mesenterica* is fairly common in hazel copses, forming soft yellowish masses, very wrinkled and up to three inches across on dead twigs still in position as well as on sticks on the ground.

The lignicolous fungi include a relatively small number of kinds of toadstools. Thin twigs taken from places where there was dense herbaceous vegetation during the summer, are sometimes thickly inhabited and delicately adorned by the lovely little *Marasmius rotula*, a gem of its kind. Stumps, felled trunks and decaying fence posts close to their base may show dense tufts of the sulphur-cap (*Hypholoma fasciculare*), ill-smelling and coloured an uninviting brimstone yellow. Trees which have obviously died recently and are still standing, may have in the ground near by, thick clumps of the honey-agaric (*Armillaria mellea*), perhaps the most dangerous fungal parasite of trees and shrubs, spreading from tree to tree by its mycelial cords, which, when old, look like leather bootlaces. Its relative, the pure-white *A. mucida*, forms handsome toadstools. It is a weak parasite on beech, fruiting on the branches of the tree, and, perhaps, unable to establish a hold until the beech has been weakened by other causes.

It is always worth while turning over dead boughs and sticks which have lain for a time on the wet earth. Almost always, in the damper part of the year, the fructifications of several kinds of 'slime-fungi', including the beautiful *Stemonites fusca*, with its dark brown, long delicate sporangia, will be found between the bough and the earth. There will be a rich crop of fungal growths closely applied to the underside of the bough, spreading in thin sheets over it. These may include forms allied to *Merulius lacrymans* (the dry-rot fungus of houses), and species of *Irpex*, *Poria* and other genera. But it is always difficult, and often impossible to name these fungi with accuracy. Living as they do between wood and earth, they can hardly disperse their spores into the air, and those spores may well be carried about by beetles, woodlice and other small animals. It is likely also that the fungi spread by the growth of their mycelia through the soil. This set of fungi includes many very common forms. The biology of the assemblage, including that of the associated small animals, would well repay a detailed study, but that study would take up much time and demand close application.

This article is a very general survey of a wide field. It mentions only a few of the kinds of fungi likely to be found in woodlands in late autumn. Much additional information may be gained from J. Ramsbottom's *Handbook of the Larger British Fungi*, published by the Natural History Museum, and the same author's *Mushrooms and Toadstools* in the New Naturalist Series published by Collins; also recommended is *Common British Fungi* by E. M. Wakefield and R. W. G. Dennis, a book which contains a large number of excellent coloured figures, as well as an informative text. The only useful pocket book available is *The Observer's Book of Common Fungi* by E. M. Wakefield, just published by Warne's, price 5*s*. Silver Leaf Disease is the subject of an Advisory Leaflet (No. 246) issued by the Ministry of Agriculture and published by H.M.S.O. (price 2*d*.)

(The line illustrations in this article are taken from the first-mentioned book, and are reproduced by permission of the Trustees of the British Museum.)

VIRUSES AND THE CONTROL OF INSECT PESTS

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Viruses, which, at all times, are of the greatest importance to man and his economy, are particularly in the news just now because of the spread of myxomatosis among rabbits in the United Kingdom. This is a good example of the biological control of a pest by means of a virus, and since viruses attack almost every kind of living organism it prompts the question, can they be used to control other obnoxious pests? In this article I propose to describe some viruses that affect insect pests and to suggest a few possible applications of this control method to them.

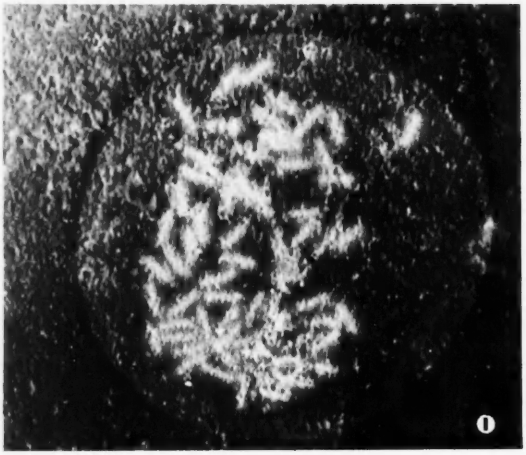
The viruses which attack insects are of the greatest interest to the virologist for a number of reasons. They are perhaps the least investigated of all the virus groups and, in consequence, many exciting discoveries are still to be made. There are evidently several different kinds of viruses, and their general behaviour, and that of polyhedral viruses in particular, is extremely interesting. Then again, the fact that some of the viruses are known to start in the cell nuclei of certain tissues allows us to pin-point the exact focus of multiplication and to examine it with the electron microscope. However, from the point of view of this article, one of the most interesting characters of insect viruses is that of latency. A familiar example of a latent virus is that of herpes simplex, or 'cold sore', in man, and this, as most people know, can be started into activity by a variety of causes, such as exposure to ultra-violet rays (sunlight) and also by infection with another virus, that of the common cold. We have good evidence for supposing that large numbers of caterpillars are already infected with a virus which apparently causes them no ill-effects unless some factor or factors starts the virus multiplying.

Indeed with some species it is very difficult to find any larvae which do not have a virus latent within them. We shall consider this point again in dealing with specific insect pests. Before discussing the possibility of using viruses to control noxious insects, I want to describe what some of these viruses look like under the electron microscope and mention certain insect pests which might be controlled by the use of viruses. As already pointed out, there are several different kinds of insect viruses, the best known being the polyhedral viruses. They are given this name because of the peculiar response on the part of the caterpillar to infection. The blood and certain tissues become filled with large numbers of polyhedral crystals in which the virus itself is contained. (Figs. 1–3.) Polyhedral diseases of caterpillars are of at least two kinds—*nuclear* and *cytoplasmic*; in the nuclear diseases the virus starts to multiply in the cell nucleus. This type of virus is usually confined to the cells of the blood, skin and tracheae. In the cytoplasmic diseases, the polyhedral bodies and virus occur in the cytoplasm and not the cell nuclei. They are found in the gut of the infected insect. It is rather an interesting fact that the virus particles in the nuclear polyhedra are rod-shaped whilst those in the cytoplasmci polyhedra are spherical. Polyhedral virus diseases attack only the larval forms of insects and they have been found in the Lepidoptera, Hymenoptera and Diptera.

A very interesting polyhedral virus attacks the well-known leather-jacket, which is the larva of the cranefly or 'daddy long legs'. This virus causes a kind of blood disease, whereby the number of blood cells is greatly increased. The virus apparently multiplies in the nucleus of the blood cells and the polyhedral crystals form round the membrane of the greatly enlarged nucleus with one edge in the nucleus and the other in the cell cytoplasm. The small virus rods are drawn into the crystal as it forms, and the larva eventually becomes almost filled with vast quantities of these crystals. (Fig. 4.)

Another kind of virus disease is known as a capsular disease or *granulosis*. In this type of disease there are no polyhedra but instead large numbers of very small granules occur, each containing a single virus rod. Granular diseases have been found in many lepidopterous larvae. (Fig. 5.)

The idea of using viruses to control insect pests is not a new one, it has been applied with considerable success in both California and Canada. The caterpillar of a butterfly (*Colias philodice eurytheme*) which is very similar to our 'clouded yellow', is a serious pest of lucerne (or alfalfa as the Americans call it) in California. Enormous numbers of caterpillars appear at intervals and devastate the crop. Natural attacks of polyhedral virus diseases occur from time to time but these cannot be depended upon to give satisfactory economic control of the caterpillar and so must be increased in scope and intensity. Usually they occur only after serious damage to the crop has already been done. The method adopted was to obtain large quantities of the polyhedral crystals. This was accomplished by breeding numbers of larvae in captivity and infecting them artificially. The polyhedra were then separated off from the dead caterpillars and stored until a sufficient quantity was obtained. Storing the polyhedra is an easy matter since they are very resistant and remain infectious even out-of-doors for at least two years. The virus suspension, containing some five million polyhedra per c.c. was then applied as a spray at the rate of five gallons per acre. For large fields an aeroplane was used, but for small fields ground equipment would be more suitable. By this means artificial epidemics of the disease were induced at a much earlier stage in the life of the caterpillar than would have happened naturally, and a good control of the pest seems to have been achieved. This is an example of control by stimulation of an already existing disease. The Canadian experiment, on the other hand, was an example of the importation of a virus disease from another country, and in this respect it resembles the Australian experiment with rabbit myxomatosis. The insect pest was the European



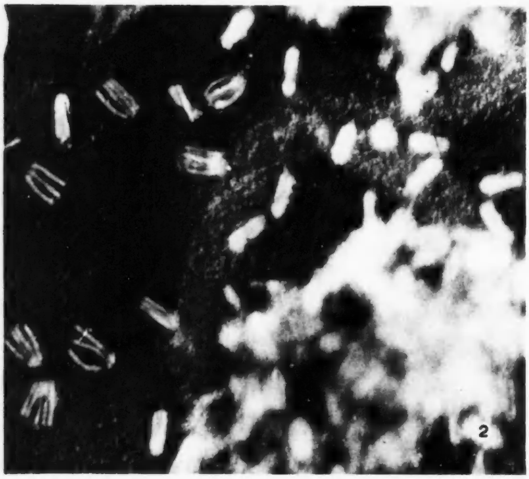


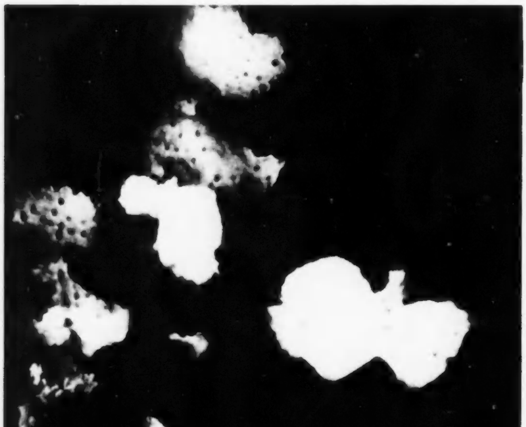
FIG. 1. Nuclear polyhedral crystal from *Philosamia cynthia* dissolved in weak alkali and photographed with the electron microscope. Note the membrane left behind and the virus rods contained within. × 21,000

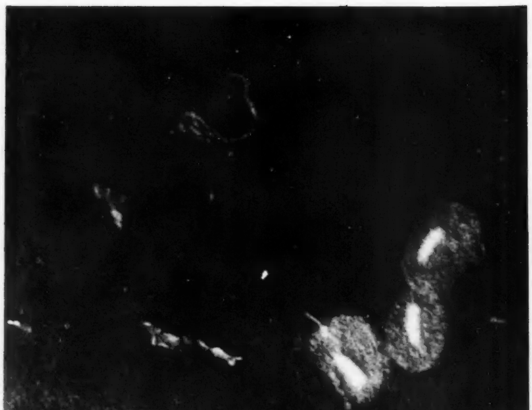
FIG. 2. Virus rods liberated from a nuclear polyhedral crystal of *Lymantria dispar*, the gipsy moth, by means of weak alkali. Note single rods and bundles of two and more. × 21,000

FIG. 3. Cytoplasmic polyhedral crystals from the larva of the angleshades moth treated with weak alkali. Note absence of membrane and circular holes which contained the spherical virus particles. × 18,000

FIG. 4. Thin section through a diseased blood cell of the leather-jacket. Note the four 'polyhedral' crystals arranged round the nuclear membrane and the virus rods in the centre of the nucleus. × 9,000

FIG. 5. Granulosis disease of the 'nettle grub'. The granules have been treated with weak alkali. Note the outer capsule, the inner capsule and the liberated virus rod. × 19,000





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pine sawfly (*Neodiprion sertifer*); the virus used was of the polyhedral type and it was procured from Sweden. This sawfly is a serious defoliating pest of pine trees in many parts of Europe and Asia, and it was first reported in Canada in 1939. By 1949 it had spread throughout most of south-western Ontario. During this time no signs of virus infection had been noticed. The virus was propagated and applied in different concentrations and by different methods. The most successful was to spray the virus by means of an aircraft. Over 94% mortality resulted three weeks after spraying, when 22 gallons of virus, containing 5 million polyhedra per c.c., and to which skim-milk powder was added as a sticker, were sprayed from an aircraft over fifty acres of sawfly-infested Scotch pine.

In Scotland this year there was a serious outbreak of the same sawfly, and a large number of larvae were sent to our laboratory at Cambridge through the courtesy of Dr. G. D. Morison of Aberdeen. From these larvae we have isolated a polyhedral virus which is probably the same as that used in Canada. The effect it has on the sawfly larvae is shown in Fig. 6. There seems therefore no reason why the virus should not be used to bring about the control of the sawfly in this country.

In considering the possibility of the control of insect pests by viruses, we have two important questions to bear in mind. First, has the particular insect pest a virus disease of its own; and secondly, if it has not, can it be given one? As regards the second question it has recently been shown by this laboratory that, contrary to accepted opinion, the polyhedral viruses of insects are not completely specific, but in many cases can be transmitted from one species of caterpillar to another. This, of course, as we shall see in a moment, increases the possibilities of this method of control.

FIG. 6. Larvae of the pine sawfly, *Neodiprion sertifer*, dying of a polyhedral virus disease. Note the characteristic hanging position of the larvae.

After this brief outline of the situation, we can consider to what insects this method of control can be applied and how far the work in our laboratory has progressed. The first insect considered in this article was the pine sawfly, so that in passing we might refer to a similar insect. This is the black-currant sawfly (*Nematus olfaciens*), of which there has recently been an outbreak. Through the co-operation of Dr. Gough of the National Agricultural Advisory Service, a number of these sawfly larvae were obtained, and one or two of them were found to be infected with a polyhedral virus. It is probable, therefore, that this sawfly also might be amenable to control by this means.

These two insects, the pine and black-currant sawflies, are cases where a virus has been found naturally affecting each species. Let us now consider two insect pests in which no natural virus disease has been observed by us. These are lepidopterous insects, and their caterpillars are well-known pests, the winter moth (*Operophtera brumata*), and the pine looper (*Bupalus piniarius*).

Before describing our attempts to infect these two insects with a foreign virus disease, it is necessary to digress slightly in order to tell something of the virus used in the experiments. Two years ago some very young larvae of the painted lady butterfly (*Vanessa cardui*), some of which were already in a moribund condition, were received from a firm that sells living caterpillars. From these little larvae a mixed infection was obtained consisting of both nuclear and cytoplasmic viruses. This mixed infection appeared to be very virulent for a number of different insects and the particular inoculum used in the present case had already been put through two separate lots of caterpillars of the small tortoiseshell butterfly (*Vanessa urticae*). Using this material, then, fifty half-grown larvae of the winter moth were fed with apple foliage contaminated with the polyhedra. Within a fortnight all the winter moth larvae were dead. Examination showed that they had died of a cytoplasmic polyhedral disease. The experiment was then repeated with the same result. Next, a small test was made of the effect of the virus on the caterpillars in their natural habitat. Of 25 larvae sleeved on a branch of apple treated with the polyhedra none survived, whereas on the untreated branch about half of the control larvae pupated. So far as this goes it promises well. The next experiment was carried out on the pine looper (*Bupalus piniarius*). Some hundreds of young larvae were collected by C. F. Rivers from pine trees in the Tunstall district, and on September 3 one hundred of these larvae were fed with pine needles contaminated with the polyhedral virus originally obtained from the larvae of the painted lady butterfly. The remainder of the pine loopers were retained as a control. On September 17 only two of the hundred experimental larvae were still alive; all the rest had died of polyhedral disease. Examination of the dead larvae indicated that they had died of a

FIG. 7. Larvae of the pine looper, *Bupalus piniarius*; on the right are caterpillars which have died with a cytoplasmic polyhedral disease, on the left are the untreated caterpillars of the same age.

polyhedral disease of the gut, in other words a cytoplasmic disease. In Fig. 7 may be seen, on the right, a sample of these dead larvae with, on the left, a sample of the same original batch of larvae which were not treated with virus and which are quite healthy. No virus disease developed in the untreated larvae.

In the cases of the larvae of the winter moth and of the pine looper, we cannot say for certain, although it is extremely probable, that the diseases which develop after infection are due to the actual viruses with which the larvae were inoculated. In view of the fact that so many larvae carry a latent virus, it is possible that the larvae died of their own latent virus, set off or 'triggered' by the foreign virus which was introduced, rather in the way that herpes in man can be stimulated by the action of the common cold virus. This, however, is a purely scientific point and does not affect the efficacy of the method of control, since the larvae die in any case.

I have already mentioned a virus disease of the leather-jacket in discussing the different types of insect viruses, and in addition to this polyhedral disease, there is also known another virus which has no polyhedra or other kind of intra-cellular inclusion associated with it. These two viruses occur naturally in leather-jackets, but under natural conditions do not appear to play a very great part in reducing their numbers.

In Ceylon there is a caterpillar known as the 'nettle grub' (*Natada nararia*), which eats the leaves and so causes considerable damage to the tea bushes. This larva is also susceptible to a virus disease which occurs naturally and is of the 'granulosis' type. (Fig. 5.)

Finally we must mention the two clothes moths—*Tineola bisselliella*, the common clothes moth, and *Tinea pellionella*, the case-bearing clothes moth. The larvae of these two moths are each susceptible to polyhedral diseases of both the nuclear and cytoplasmic types. Some preliminary work has already been done on the control of these larvae by means of these viruses, but only on a small scale, and in enclosed places. Under these conditions the virus has worked satisfactorily.

In this article I have mentioned seven harmful insects, each of which is attacked by one or more viruses. It seems clear, therefore, that there will probably be no very great difficulty in finding a virus to attack an insect pest, provided it belongs to one of the three orders, Lepidoptera, Hymenoptera and Diptera. The chief difficulties would arise in the preparation of sufficient virus and its proper application. Obviously this would be a whole-time job and really needs an organisation devoted exclusively to this end. However, if viruses prove a successful means of insect control such an organisation might eventually materialise.

In view of the availability of so many new and effective insecticides the reader may wonder whether the development of control by means of viruses is really necessary. There are two facts about this method of biological control which are relevant and deserve emphasis. One is that the polyhedral crystals are very stable and retain infectivity for a much longer period than an insecticide remains effective. The other fact is that the virus is aimed at a specific insect only and does not, like a contact insecticide, slaughter all and sundry. Experience with the nettle grub of tea and the winter moth illustrates this point. It appears quite possible to control the nettle grub on the tea bushes by the use of D.D.T., but this is invariably followed by a heavy attack of red spider, presumably because the insecticide has killed off the enemies of the red spider. Since the use of poisonous insecticides is not recommended for use on tea bushes, the application of an insect virus would seem an obvious solution. Similarly, with the caterpillar of the winter moth heavy attacks of red spider follow the application of D.D.T. sprays to apple trees.

In conclusion, a word of caution is perhaps necessary against being too optimistic about the success of this new weapon. Biological control is notoriously chancy because there are so many variable factors. However, the success so far achieved certainly encourages us to investigate the matter further.

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ULTRAMICROCHEMISTRY

BURRIS B. CUNNINGHAM

In 1943 engineers of the American atomic bomb project decided the design of chemical processing plants costing hundreds of millions of dollars on the basis of a few experiments carried out with quantities of plutonium so small as to be scarcely visible. The information gained from these tiny samples helped to shorten by months the time needed to produce plutonium in militarily useful amounts.* This case is an example of the utility and importance of the new field of chemical investigation known as ultramicrochemistry. With its techniques the writer and his associates, L. B. Werner and M. Cefola, had isolated microscopic quantities of plutonium in pure form, and chemists at the University of Chicago Metallurgical Laboratory had performed the necessary experiments to determine its chemical properities.

At the time only a few chemists had any acquaintance with ultramicro methods. They are now somewhat better known and have been put to work in various areas, notably biochemistry.

Ultramicrochemistry is an invasion of a world almost unbelievably small with unbelievably delicate instruments. It is the daughter of microchemistry, but a thousand times more refined. To have obtained the needed information about plutonium the methods of classical microchemistry would have required about a hundred times as much plutonium as was available. An ultramicrochemist works with amounts of material a million times more scanty than in conventional chemistry: his samples are measured not in grams (about the weight of a fly) or even milligrams, but in micrograms—a millionth of a gram!

The objectives of the ultramicrochemist are the same as those of any other chemist: to weigh and measure substances, determine their melting and boiling points, measure the amount of heat absorbed or liberated in their chemical reactions, observe their interactions with various kinds of electromagnetic radiation, follow their chemical behaviour, and so on. But to devise reliable techniques for doing all this with the minuscule samples available is a problem of great technical difficulty.

Research on extremely small quantities of material can be done with the methods of tracer chemistry. Tracer work is restricted, however, to situations in which the substance is highly diluted. The microchemist and the ultramicrochemist work with substances in the pure state or in relatively concentrated solution.

Ultramicro methods did not originate with the atomic bomb project, although they were greatly expanded under its impetus. Long before World War II systems of ultramicroanalysis had been developed by the pioneering efforts of such men as P. L. Kirk and Roderick Craig at the University of California, A. A. Benedetti-Pichler at Queens College in New York, K. U. Linderstrom-Lang at the Carlsberg Laboratories in Denmark, P. F. Scholander at Swarthmore College and E. J. Conway at the University of Dublin. Their methods were designed primarily to meet a single technical problem: the exact measurement of very small volumes of liquid, of the order of a hundredth of a millilitre—about one 3000th of a fluid ounce. Of course other operations, such as filtering, stirring and so on, also had to be developed for this small-scale work, but the problem was primarily one of measurement.

Two devices for making such measurements were developed. One of them, simply a refinement of the familiar kitchen measuring cup, is a graduated vessel of very small diameter—hardly more than an upright capillary tube. The error involved in reading off a volume from a graduated tube is equal to the error in matching the liquid surface to the reference line times the cross-sectional area of the vessel. Using the best equipment, it may be taken as a rough rule that the uncertainty in adjusting a liquid level to a reference line is about five thousandths of an inch. If the volume to be measured is a microlitre, say, and the error is not to exceed half of 1%, the diameter of the measuring tube cannot be more than a hundredth of an inch. With so small a diameter, irregularities in the bore would produce large errors in volume. Therefore the volume of these measuring tubes is usually determined directly, by weighing them empty and when filled with mercury. Another difficulty arises if the measured liquid is to be transferred out of the measuring tube, because a considerable and variable portion of the liquid will stick to the tube walls. This can be overcome by coating the walls of the tube with water-repellent material.

The second principle of small-scale volume measurement, applied a number of years ago by Scholander, avoids both difficulties. In Scholander's system the liquid to be measured is put in a hollow cylinder of metal or plastic which connects at one end to a very fine glass capillary tube. The other end of the cylinder is drilled to admit a closely fitting cylindrical plunger of small and precisely known diameter. The plunger is pushed into the cylinder by means of a precision micrometer screw which measures its advance very sensitively. If the cylinder and glass tube are filled with the liquid to be measured and the plunger is advanced, some liquid will be pushed out of the capillary. The volume escaping will be precisely equal to the volume of plunger entering the chamber. This volume can be calculated from the diameter and the distance the plunger has been moved. Scholander's set-up, which used a plunger no thicker than a small sewing needle, achieved a precision of about one 10,000th of a microlitre.

The techniques of small-scale volume measurements have found a number of important applications in biochemistry. Certain blood chemistry studies that used to require large expensive experimental animals to provide enough material for analysis can now be done with mice. Ultramicro methods can determine where and under what circumstances

* Ultramicrochemistry was equally important in the British atomic project: from 20 milligrams of plutonium—just enough to cover a pin's head—Dr. R. Spence's team working first at Chalk River, and then at Harwell, obtained the basic chemical data needed to design the great plutonium production plant at Windscale.

insecticide accumulates in the body of an insect. Embryologists have found many uses for the techniques. An interesting example is the work of the British investigator N. G. Heatley, who has been able to show that in salamander eggs the regions destined to develop into the back part of the animal have an extra amount of the starch-like substance called glycogen. By implanting a little glycogen in other parts of the egg he was able to cause a primitive spinal tube to develop there.

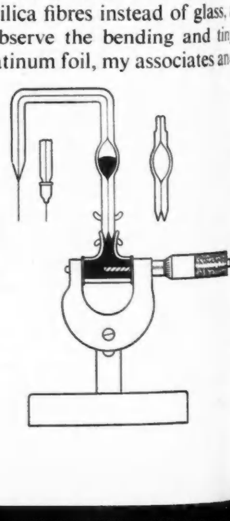
Linderstrom-Lang has been one of the most active workers in applying ultramicro methods to biochemical research. In addition to small-volume measurements he used two other delicate techniques. He adapted the familiar little toy known as the Cartesian diver to measuring small quantities of gas. A home-made diver usually consists of a small open medicine bottle that is partly filled with water and floated upside down in water in a large, wide-mouth container, such as a milk bottle. A sheet of thin rubber stretched across the mouth of the larger bottle makes an air-tight seal. When you push the rubber sheet down with your finger, compressing the air in the milk bottle slightly, the increase of pressure is communicated through the water to the air inside the smaller bottle, or 'diver'. Since this air is compressed, more water enters the diver. Eventually so much water is forced in that the diver loses buoyancy and sinks to the bottom of the milk bottle. If you remove your finger, allowing the air to expand, the diver rises to the surface again. There is a definite pressure and volume of air that will just keep the diver afloat, and any internal change in the gas pressure inside the diver can be measured by the amount of pressure adjustment that must be made from outside to keep it just floating. Thus a chemical reaction taking up oxygen inside a diver can be followed by noting the changes in pressure. Linderstrom-Lang's divers, containing only a few microlitres of air, were used in this way to study such things as the utilisation of oxygen by small bits of living tissue.

The second technique developed by this Danish biologist also depends on a flotation principle. A tall glass cylinder is partly filled with one organic liquid and then filled the rest of the way with a second, which is miscible with the first but slightly lighter. Care is taken to minimise mixing of the two liquids until the vessel is all filled. Then it is stirred gently so that mixing takes place near the dividing line between the liquids. This gives a region in which the density is graduated more or less uniformly from the lower to the higher value. A drop of water solution, not soluble in the organic liquids and having a density greater than the lighter but less than the heavier one, is put in at the top of the vessel. The droplet sinks until it comes to rest in the region where the density of the surrounding liquid is the same as its own. If the drop of solution contains substances which are reacting chemically in such a way as to change the density of the solution, it will seek a new level and the progress of the reaction can be followed from the drift of the drop. In this way Linderstrom-Lang studied the action of isolated enzymes on proteins. (As proteins break down, the density of the solution increases.)

The water-drop trick is an indirect method of weighing small quantities of liquid. Let us now consider how ordinary weighing operations are done in ultramicrochemistry. Early in this century the Australian chemists B. D. Steele and K. Grant built the first balance that could operate in the microgram range. They made the apparatus entirely of fused silica, a precedent that has been followed by nearly all later makers of ultramicrobalances. Their instrument consisted of a beam of fused silica rods balanced on a prism-shaped lump of silica with a fine knife-edge which rested on a small plate of polished quartz. It was so sensitive that the English chemist Sir William Ramsey could use it to weigh about a hundredth of a cubic inch of radon—the gaseous decay product of radium. By this measurement Ramsey was able to determine the atomic weight of radon and thus to verify Lord Rutherford's hypothesis of radioactive decay. Rutherford had suggested that the first step in radium disintegration should be the emission of a helium atom, whose atomic weight is four. Ramsey obtained an atomic weight for radon just four less than that of radium.

A serious drawback to the Steele and Grant balance was the fineness of its knife-edge; the slightest particle of dust under the edge rendered the balance useless. The difficulty was overcome by the Swedish chemist Hans Pettersson, who put an axle through the centre of the beam and suspended the axle by fine silica threads from an overhead frame. Pettersson's balance was remarkably accurate (to about six 10,000ths of a microgram). In fact, it has been exceeded in accuracy only by a balance built recently in the author's laboratory. Fine as it was, however, it was not good enough to enable Pettersson to realise his hope that he might detect the weight gained by a body as its temperature is increased, in accordance with Einstein's then novel equation $E = mc^2$.

Neither the Pettersson nor the Steele and Grant balance was well adapted to general chemical experimentation, and they are no longer used. The first ultramicro weighings on pure plutonium compounds were carried out with a very simple balance, which was a refinement of the one invented in 1901 by E. Salvioni, an Italian biochemist. His instrument consisted of a thread of glass about three times as thick as a human hair and about four inches long, bent at one end to form a small hook. The straight end was fastened to a support so that the fibre stuck out like a tiny fishing pole. The object to be weighed was hung from the hook, and its weight was calculated from the amount of bending in the fibre. Using silica fibres instead of glass, a high-power microscope to observe the bending and tiny weighing pans of very thin platinum foil, my associates and



Scholander's micrometer burette. The titrating liquid is moved by the mercury, which is forced into and out of the capillary by a plunger actuated by the micrometer screw.

I were able to weigh plutonium compounds with an accuracy of a hundredth of a microgram. The Salvioni balance obviously cannot support much weight, however, and manipulating the minute weighing pans is inconvenient.

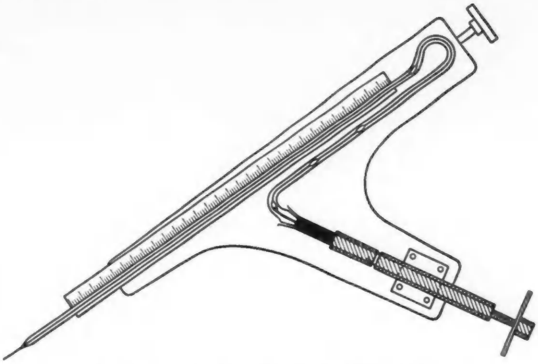
A more generally useful balance for routine ultramicro weighings has been devised by Kirk, Craig, J. E. Gullberg and R. Q. Boyer at the University of California. Its beam is a plane triangular framework of fused silica fibres, weighing but 15 milligrams altogether. The beam is supported at its centre by a horizontal fibre, which tends to twist as weight is added to one end.

As a crude analogy to this balance, imagine a thick rope stretched taut between two trees. A thin rod of iron is thrust horizontally through the strands of rope near its centre. An object hung at one end causes the rod to rotate, twisting the rope, until the torque (turning force) due to the weight is equalled by the tendency of the rope to untwist. If we know how much torque is necessary to produce the observed twist in the rope, we can figure out how much the object weighs. In the actual balance a fibre of fused silica, an almost perfectly elastic material, serves as the 'rope'.

In the set-up thus far described computation of the weight would be unnecessarily complicated. The torque due to the weight depends not only on the weight and on its distance from the supporting fibre but also on the angle through which the rod has turned. (If it were to turn through 90 degrees, for example, so that the weight hung straight down, there would obviously be no torque.) It would be more convenient if we could keep the rod horizontal, so that the weight exercised its maximum torque throughout the weighing. To accomplish this we untie one end of the fibre and clamp it to the hub of a vertical wheel supported in a rigid framework and left free to turn. Now when a weight is hung from the bar we can turn the wheel until the counterbalancing twist in the fibre restores the bar to the horizontal position. We note the amount of turning required to restore the beam to the 'null' position, and, knowing the elastic torque of the twisted fibre, we can compute the weight of the object with a high degree of accuracy.

Using a torsion fibre about a thousandth of an inch in diameter and two inches long, a torsion wheel accurate to a minute of arc and twin microscopes focused on a small section of the fibre at each end of the beam to observe its rotation, weighings accurate to a hundredth of a microgramme can be carried out as rapidly and as easily as weighings on the macro scale. Because fused silica is very strong, we can place as much as 25 milligrams on each side of the balance, or more than two million times as much mass as the balance will detect. Naturally the balance system must be shielded from all disturbing air currents. The silica must be plated with a thin coating of gold to make it conducting. Otherwise, electrostatic charges could build up on the silica and produce forces many times greater than the small forces we are attempting to measure in the weighing process.

The elastic properties of silica torsion fibres are not actually known with sufficient accuracy to calculate weight directly from the amount of twist; the instrument has had to be calibrated with a small amount of residue from an evaporated solution of precisely known weight.



A universal-type capillary burette, 0·5 mm. diameter. The flow of liquid is controlled by a screw plunger.

Various models of ultramicrobalances have been tested in the last few years and the instruments are beginning to be available commercially. Weighings accurate to a hundredth of a microgram are now routine. More sensitive balances have been built, but they demand more elaborate techniques for obtaining precision measurements.

While we have been concerned here mainly with the measurement of volume and weight, which is the core of ultramicrochemistry, we should also mention some of the ultramicro devices for determining other properties. For chemical analysis there is paper chromatography, which can separate and identify extremely small amounts of substances in a complex organic compound. Tiny samples can also be analysed by X-ray, microwave and infrared spectroscopy.

For the ultramicro measurement of heat there are as yet no truly precise techniques. Microcalorimeters, capable of measuring heat down to a few tenths of a calorie, have been known for some time. But an ultramicrocalorimeter, which would have to detect a few 10,000ths of a calorie, does not exist. However, such small quantities of heat can sometimes be measured indirectly by the laws of thermodynamics. For example, the heat of solution of microgram quantities of transuranium elements has been determined by measuring the effect of temperature on their solubility.

Ultramicrochemistry, then, already has at its disposal a wide variety of methods for studying matter. But it would be misleading to give the impression that chemists can deal with matter on the microgram scale as expeditiously and conveniently as in the familiar macro world. Human anatomy is simply not built to manipulate matter on so fine a scale as this. To come to grips with the ultramicro world at all the ultramicrochemist must resort to precision manipulators, lenses and other ingenious mechanisms which inevitably stand between him and his samples.

(This article is reprinted from "Scientific American" by permission of the Editor. During the war its author was in Prof. G. T. Seaborg's group which worked on plutonium and other transuranium elements. The illustrations are taken from P. L. Kirk's "Ultra Microanalysis", 1950, published by John Wiley of New York, and by Chapman & Hall in Britain.

FAR AND NEAR

Night Sky in November

The Moon.—Full moon occurs on Nov. 10d 14h 29m U.T., and new moon on Nov. 25d 12h 30m. The following conjunctions with the moon take place:

November				
3d 19h	Mars in conjunction with the moon		Mars	5° S.
15d 14h	Jupiter	,,	Jupiter	2° N.
24d 03h	Saturn	,,	Saturn	6° N.
24d 03h	Mercury	,,	Mercury	6° N.
24d 07h	Venus	,,	Venus	2° N.

In addition to these conjunctions with the moon, Mercury is in conjunction with Saturn on Nov. 24d 01h, Mercury 0·4 S., and also in conjunction with Venus on Nov. 25d 05h, Mercury 3° N., and Venus is in conjunction with Saturn on Nov. 24d 07h, Venus 2° N.

The Planets.—Mercury is a morning star but too close to the sun to be observed in the early part of the month. On Nov. 15 and 30 it rises 5h 25m and 6h 25m respectively, in the latter case only 1h 15m before sunrise and will not then be easily seen. Venus is unobservable for a great part of the month and is in inferior conjunction on Nov. 15. On Nov. 30 it rises two hours before the sun and can be seen in the eastern sky—stellar magnitude -4. Its close approach to Saturn about that time has already been pointed out. Mars, an evening star, sets at 22h 10m during Nov. Its eastward movement from Capricornus into Aquarius is easily observable and its stellar magnitude varies from 0·1 to 0·5. The decrease in brightness, owing to its increasing distance from the earth—from 91 to 111 millions of miles during the month—can be detected with careful observation. Its close approach to the moon on Nov. 3 has been referred to earlier. Jupiter rises at 21h 35m, 20h 45m and 19h 40m on Nov. 1, 15 and 30 respectively. Its stellar magnitude varies from $-1{\cdot}8$ to -2 during this time; owing to the decrease in its distance from the earth from 462 to 424 millions of miles there is a slight increase in its brightness, as might be expected. Saturn is in conjunction with the sun on Nov. 5 and is unobservable in the early part of the month. It rises less than an hour before the sun on Nov. 15 but later in the month it can be easily seen in the morning hours, and rises at 5h 30m on Nov. 30—more than two hours before sunrise. It will be fairly close to the moon on Nov. 24 but as the moon is new on Nov. 25, and the crescent may be difficult to observe, this fact will not be of much interest. On the same morning Mercury and Saturn will be close together and Mercury can then be seen shining like a bright star, stellar magnitude $-0{\cdot}6$; it rises on that date about one and a half hours before sunrise.

The Andromedids—the meteors associated with Biela's Comet—attain their maximum about Nov. 28 and as the moon is then only three days old it should be possible, with favourable weather conditions, to see them. They are slow meteors and this makes it easier to observe their paths; if these are produced backwards they converge to a small area close to γ Andromedae—hence their name though they are also known as the Bielids after Biela's Comet which was expected to return in 1872 but which, if it disappointed astronomers by not keeping to scheduled time, created intense interest by supplying a most wonderful display of meteors. The comet will never be seen again but its debris appears each year towards the end of November in the form of a shower of meteors.

Professor Oliphant's Rutherford Memorial Lectures

The Royal Society has announced the name of the Rutherford Memorial Lecturer for 1955. He is PROF. M. L. E. OLIPHANT of the Australian National University. An Australian by birth, he followed in Rutherford's footsteps, coming to England as an 1851 Exhibitioner and joining the Cavendish Laboratory (where, of course, he did research under Rutherford). He became Poynting Professor of Physics at Birmingham University in 1937, returning to Australia when the National University for postgraduate research was established.

As Rutherford Memorial Lecturer, Prof. Oliphant will be visiting India and Pakistan.

Gauge Making and Measuring Devices

The fifth publication in the series of "Notes on Applied Science" produced by the National Physics is entitled *Gauge Making and Measuring* (published by H.M. Stationery Office, price 3*s*.). Primarily it is intended to make available to gauge makers a comprehensive body of information on the subject. It is hoped also that the publication will be helpful to students of metrology who intend to take the National Certificate Examinations in either mechanical or production engineering.

The subject of gauge making is treated from both the theoretical and practical workshop angles. The section covering general measuring equipment deals with all the measuring devices likely to be encountered in general engineering practice, including gauges, micrometers, comparators and optical measuring instruments. In the final section ring, gap, taper and other special types of gauges, including profile gauges, are described in detail.

The appendices include tables for use in taper measurement and a bibliography covering the various fields of metrology.

Barts Hospital's 15 MeV Linear Accelerator

The largest and most powerful linear accelerator designed for medical purposes is now ready for installation at Barts Hospital, London. This 15 MeV travelling-wave instrument will be operated under the direction of PROF. J. ROTBLAT of the hospital's Physics Department.

The machine was produced by the same team of physicists and engineers at Mullard Research Laboratories who developed the linear accelerator for Newcastle upon Tyne General Hospital, which was described by T. R. Chippendale and M. G. Kelliher in the October 1954 issue of DISCOVERY (pp. 397–404).

Professor Bernal Receives Stalin Peace Prize

On September 23, PROF. J. D. BERNAL was presented with his International Stalin Prize for the Consolidation of Peace—in the form of a gold medal and a diploma—from the hands of Academician D. V. SKOBELTSYN, chairman of the prize committee. The presentation was made in the Kremlin. Afterwards the First Secretary of the Central Committee of the Communist Party of the Soviet Union, N. S. Khruschev, received Professor Bernal and had a long talk with him.

Harwell Starts Courses on Atomic Power

As a step towards encouraging industry to play a greater part in the development of atomic power, the Atomic Energy Authority has opened a Reactor School at Harwell. The new school provides, for a fee of £250, a three months' course of training for staff from industrial concerns to learn the techniques by which heat from atomic piles can be converted into useful power. The first course started on September 27.

During the debates in Parliament on the setting up of the Atomic Energy Authority it was emphasised that one of the tasks of the Authority would be to increase industrial participation in the atomic energy project. Before this is possible, it is necessary for staff from industry to be trained. The provision of such training is one of the principal objects of the new school. Priority is being given at first to staff of firms already acting as contractors to the Atomic Energy Authority. Some new graduate members of the Authority's own staff will also train in the school.

Three courses will be held each year starting in September, January and May, each course lasting three months. The syllabus includes lectures and individual instruction in Nuclear Physics, Reactor Physics, Metallurgy and Reactor Engineering, as well as experimental work. About 25 students can be accommodated.

Applications for places in the school have to be made to the Manager, Reactor School, A.E.R.E., Harwell, Berkshire, and should give sufficient information for the Management Board to assess whether the student has the required academic standard for entry to the School. It is expected that all students will be Physics or Engineering graduates or else have had considerable theoretical and practical experience in at least one branch of science or engineering.

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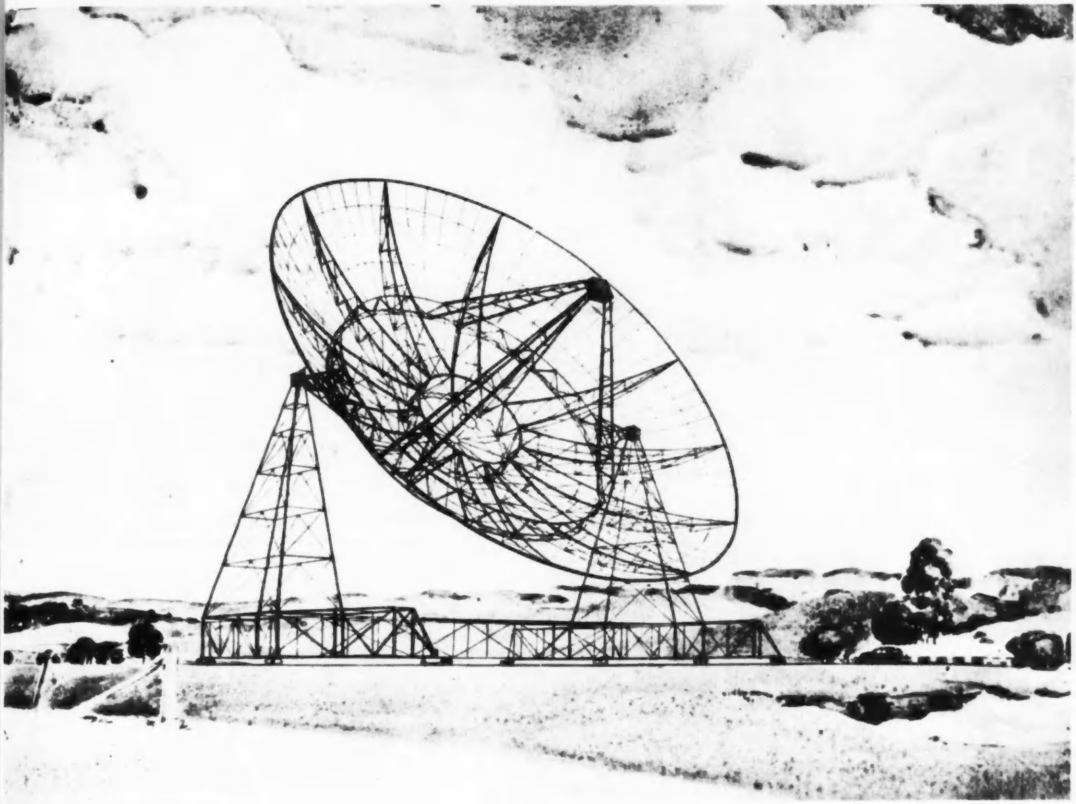

RADIO ASTRONOMY IN AUSTRALIA AND NORWAY

(Top) *Australia has announced tentative plans for a huge radio telescope to give the same kind of coverage of southern skies as Prof. Lovell's telescope now being erected at Jodrell Bank will give in the northern hemisphere. The Australian instrument will cost £A500,000, and the Carnegie Corporation has already promised £A110,000 towards it. The site that has been selected is near Sydney, and the design and operation of the telescope will be the responsibility of the Radio Physics Division of the Commonwealth Scientific and Industrial Research Organisation, Australian equivalent of D.S.I.R. The Australians favour a design resembling that of the Jodrell Bank instrument, with a bowl 250 ft. in diameter supported by two towers.*

(Right) *The new Harestua solar observatory, recently opened in Norway in forest country far north of Oslo, is equipped with both optical and radio telescopes so that the astronomers can keep the sun under continuous observation regardless of visibility conditions.*

Mathematics up to subsidiary Degree standard is necessary, particularly for the Reactor Physics lectures.

Portable Atomic Power

Practical atomic power units are now being vigorously developed in the U.S.A. and the latest one to be reported is a compact 1700-kilowatt power plant that can be broken down and airlifted piece by piece to U.S. bases overseas. This pile, which is officially called the Army Package Power Reactor, is being developed by the U.S. Army and the Atomic Energy Commission. According to *Time* (30.8.54) it is designed to generate enough power for a town (or military base) of 1700 people. When fully assembled, it will fit into a building 42 ft. high but only 29 ft. wide by 80 ft. long (smaller than a standard Army barracks).

The U.S. Army will build the new model at the Army Engineer School at Fort Belvoir, Va., 18 miles down the Potomac from Washington. Estimated completion date: 1956 or 1957. Despite a high initial cost of some $8,000,000, the portable reactor is regarded as promising from the economic standpoint. Remote U.S. bases, especially those in the Arctic, burn up vast amounts of oil for heat and diesel-generated electricity at a cost that sometimes reaches $42 a barrel. Using the reactor and its enriched uranium fuel, the U.S. Army could free ships and planes for other duties; 1 lb. of easily transported uranium contains as much energy as 6350 barrels of fuel oil.

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Details of a new experimental atomic power pile that "may give the lowest-cost electrical energy from fission heat" have just been revealed by Dr. Clarke Williams of the U.S. Atomic Energy Commission's Brookhaven National Laboratory, Upton, New York.

This reactor is known as the LMFR—the letters stand for 'liquid metal fuel reactor'. It is designed to 'breed' new fuel for itself as part of its normal operation, an important factor that would help to reduce its cost of operation.

"LMFR would provide the first usage of a liquid metal alloy, in this case uranium-bismuth, as the fuel stream to interconnect continuous processes," Dr. Williams states. "The uranium used would be of atomic weight 233, a variety, or isotope, capable of splitting, or fissioning, as does the more commonly known uranium-235. Fission of the U233 atoms would occur in the LMFR core, a perforated graphite sphere five feet in diameter. In the process, atom fragments called neutrons would fly out, splitting other atoms, releasing more neutrons, and thus maintaining a chain reaction. The chain reaction would depend upon the amount of U233 fuel present, and the shape and size of the graphite which moderates or slows down neutrons to speeds most favourable for fission.

"Considerable heat would be given off in the fission process, and would be promptly conveyed by the molten uranium-bismuth alloy out of the core," explains Dr. Williams. "This substance would transfer its heat to liquid sodium outside the reactor proper. As in other schemes for utilising nuclear power, the sodium would deliver the heat to water, producing steam to spin a turbine which would drive a generator of electricity."

Surrounding the core of the reactor there will be a graphite structure through which will flow a mixture of thorium and bismuth, an arrangement which is called a 'blanket'. The excess neutrons from the fissioning U233 atoms in the core will be captured by the thorium in the surrounding blanket and form more U233. LMFR is therefore a 'breeder pile'.

The Thermofor 'Cat-Cracker' at Coryton

The special feature of the new Coryton refinery of Vacuum Oil (near Tilbury, Essex), which the Queen Mother officially inaugurated on May 27, is the Air-Lift Thermofor catalytic cracker. This 'cat-cracker' is the first of its kind to be erected in Britain. Some 35 units of this type were built in the U.S.A. just after the war. Their purpose is the production of high-octane petrol.

The early 'cat-crackers' employed fixed beds which soon became fouled with carbon and required periodical cleaning. Thermofor 'cat-cracker' (TCC) units of early design allowed the catalyst—pellets of a silica-alumina complex with a highly porous structure—to fall by gravity through the reactor and regenerator. It was then returned to the top of the reactor by means of a bucket elevator. The Air-Lift unit gets its name from the fact that the regenerated catalyst is blown by low pressure air (about 2 lb./sq. inch) nearly 300 ft. up a pipe to the top of the reactor, whence it once more falls by gravity. The new unit combines the advantages of easier and simpler operations with greater flexibility to process a wider range of stocks. Investment and operating costs have been reduced, but at the same time the Air-Lift TCC retains all the basic advantages of high liquid recovery, high catalyst activity, high cracking efficiency and high gasoline-to-coke ratio.

According to *The Chemical Age* (May 22, 1954, p. 1139), the TCC process can be designed to operate on catalysts varying in size from granules of about 60 mesh to lumps or pellets of 3 mesh or coarser, but a synthetic 'bead' catalyst has been specifically developed. This is in the form of small spherical particles, about 4 to 10 mesh in size, resembling translucent glass beads, and with great strength, ruggedness and stability. The activity of the catalyst is due to a very high porosity which imparts large surface areas per unit weight—400 or more sq. metres per gram.

Royal Commission for the Exhibition of 1851: Awards for 1954

The Royal Commission for the Exhibition of 1851 has awarded senior research studentships for 1954 (value £600 a year for two years): Miss A. I. Bailey (Witwatersrand), Dr. G. A. Horridge (Cambridge), R. Hicks (Wales), A. D. Walker (Bristol). The Commission has also awarded the following overseas scholarships for 1954 (value £450–500 for two years). *Canada:* M. J. Fraser (Dalhousie), M. Onyszchuk (McGill and Western Ontario), J. A. Kuehner (Bishops and Queen's University, Kingston). *Australia:* P. J. Stephenson (Queensland), F. W. Eastwood (Sydney). *New Zealand:* G. N. Malcolm (New Zealand). *South Africa:* Dr. S. Papert (Witwatersrand). *Republic of Ireland:* Dr. M. F. Maguire (Ireland and Aberdeen). *Republic of India:* K. Aghoramurthy (Madras and Delhi), S. Chandrasekhar (Nagpur).

National Research Council of Canada Fellowships for Medical Research

Each year the National Research Council of Canada has awarded the following medical fellowships, totalling 76,900 dollars plus travelling allowances, for research at the institutions indicated:

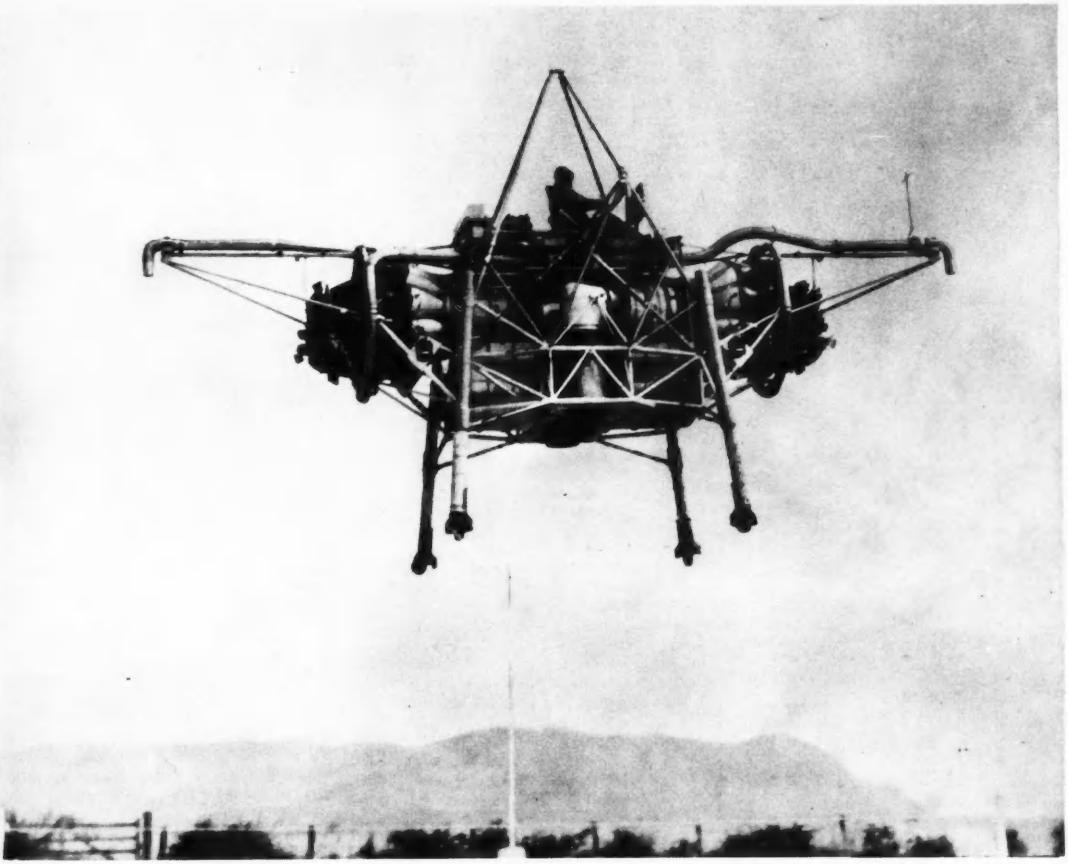
Senior Medical Research Fellowships: Dr. W. G. B. Casselman, Dr. C. N. Crowson, Dr. P. C. Fitz-James, Dr. R. W. Gunton, Dr. F. C. Heagy, Dr. H. Kalant, Dr. J. T. Nichol, Dr. J. W. Pearce.

Graduate Medical Research Fellows: Dr. D. E. Bergsagel, Dr. R. W. Cornett, Dr. T. E. Cuddy, Dr. A. Davignon, Dr. Florence M. Hill, Dr. N. Kalant, Dr. S. J. Klebanoff, Dr. Dorothy Ley, Dr. A. Malkin, Dr. J. C. Nixon, Dr. J. E. Nixon, Dr. P. Pollock, Dr. Ingeborg C. Radde, Dr. R. F. Scott, Dr. Joan M. Vale.

Reducing the Noise of Grounded Aircraft

With the ever-increasing power of aircraft engines, the problem of the noise made by engines undergoing test has become more acute. Intensive work on this problem has been carried out, and now one British company, Vickers-Armstrongs Ltd., has just revealed one result of this effort which offers a good measure of noise control. This takes the form of a pen, with sound-proofed walls, into which the aircraft is inserted when running-up the engine. The end of the jet efflux pipe of the engine is positioned in front of a 'muffler' like those used to silence the test beds of engine manufacturers. Before the completion of the new pen, whenever the Rolls-Royce Avon engine of a Swift fighter was being run at full throttle conversation was virtually impossible in the factory offices a quarter of a mile away. Now, with the pen in use, most of the office staff do not even know when an engine is being tested.

The walls of the pen are about 12½ ft. high and they completely enclose the aircraft on test on three sides. The fourth side is made up of two sliding doors, made of steel—but lined with sound-proofing material. In the wall opposite the doors, there is an opening for the 'muffler', aligned so that it is opposite the end of the Swift's jet pipe. The total length of the 'muffler' is about 45 ft. It consists of a metal tube of increasing diameter filled with a large number of baffle plates.



The highly experimental plane nicknamed the 'flying bedstead' represents a very early stage in a research and development programme, the end point of which is intended to be an operational aircraft capable of 'vertical take-off'. This mock-up was constructed by Rolls-Royce under a Ministry of Supply research contract; the simplest and lightest framework was built which could use existing engines. Two Nene engines are set horizontally in opposition, one at either end of the framework. The jets from the engines are ducted through 90 degrees so that both engines discharge vertically downwards under the machine's centre of gravity.

The side walls of the pen accommodate shelters in which the maintenance crews can watch the aircraft under test while sheltered from the weather.

It is not yet possible to reduce economically the noise of aircraft in the air, but it is clear that the new pen will go far towards making the huge modern aero-engines quieter on the ground.

The Helicopter comes into its Own

The helicopter has been slow to develop since the original invention of Louis Breguet in 1907, but it is now coming into its own in spite of the opposition of conservative officials who influence Government policies in respect of aviation. The Society of British Aircraft Constructors now announces that over two hundred helicopters have been ordered from the British Aircraft Industry for the British Services. One hundred of these are of the small single-engined type and will be used mainly for communications and rescue work; about one hundred more will be larger twin-engined, twin-rotor machines which among other duties will be used for anti-submarine work. There is also an order for a number of large single-engined helicopters for general duties with the Royal Air Force and Royal Navy.

At present, the R.A.F. is operating about twenty small helicopters, and more are in service with the Royal Navy and the British Army. A further fifty small helicopters—Westland *Dragonflies* and Bristol *Sycamores*—will be delivered over the next twelve months. For the future there is the large Westland *Whirlwind* and, somewhat further off, the twin-engined Bristol *173*.

These increased Service orders for helicopters reflect a rapidly growing interest in rotor-wing development. Government expenditure on helicopter research and development, which was non-existent in 1945–6, and was £1½ million in 1953–4, is being doubled in 1954–5. The money is being used to expand development generally, but particularly of the turbine-powered helicopter. Two companies—Fairey and Percival—are building prototype turbine-powered helicopters.

The industry is also expanding its own helicopter research facilities. Saunders-Roe, for example, are flying the *Skeeter* as a private venture, in the hope that it will be adopted by the Services as a two-seat trainer.

The plan to use helicopters for anti-submarine work revolves round a new technique for 'dunking' sono-buoys. The sono-buoy is a small 'listening' device, which, when lowered into the sea, picks up echoes from an enemy submarine and

relays the bearing of the echo back to a central control-point. Once two different bearings are obtained, the actual position of the submarine can obviously be plotted. The helicopter spotting technique will employ sono-buoys suspended from the helicopter and 'dunked' in the sea. When one 'echo' from the submarine has been received, the helicopter can hover to another position and 'dunk' the sono-buoy again there.

The British Army's interest in helicopters has been greatly increased as a result of a high-level study recently made of the impact of atomic weapons on the whole tactics and strategy of armies. It was discovered that the large fleet of wheeled vehicles, which has become a necessary accompaniment of the modern army, will be very vulnerable to atomic attack. As a result, the army has made a study of the extent to which "wheeled vehicles can be carried by air". The army's intention, as a result, is to introduce helicopters to the maximum extent, because it is felt that these flying 'jeeps' and '15 cwt.' will be invaluable to the modern army when atomic weapons are used.

Readers who want an account which does full justice to the helicopter's versatility are referred to the article in DISCOVERY, August 1951, pp. 260–3.

Fire and Atom Bombs

Britain's Fire Research Station has been studying the fire hazards involved in atomic bombing, and has now published its conclusions as an official bulletin entitled *Fire and the Atomic Bomb* (H.M.S.O., 1954, 30 pages, price 2*s*. 6*d*.).

The destructive power of an atomic bomb is measured by the amount of energy it releases. The bomb dropped on Nagasaki—now referred to as a 'nominal atomic bomb' and used as a yardstick for atomic weapons—released as much energy as the explosion of 20,000 tons of TNT. The flash of a bomb of this type can be divided into two periods. The initial flash is blue-white and lasts about a hundredth of a second. The longer flash which follows lasts for three seconds, during which it changes its colour from blue-white to cherry red. One second after the exploding of the bomb the fire ball would appear at a distance of one mile to have a diameter twenty times that of the sun. It would have a peak temperature of 7000°C, i.e. 1500°C higher than that of the surface of the sun. The heat given off would be sufficient to cause fires up to a distance of two miles from the point of the explosion.

There would be little danger of a continuing fire within the area of total destruction. In this area, which would have a radius of half a mile, rubble would dilute combustible material to an extent that would limit the spread of fire. In the area extending from the fringe of the central area to a radius of two miles there would be very great danger of serious fires. The heat given out by the bomb would be sufficient to ignite wood and textiles within that area. Within the fire danger zone wooden doors and window frames would be likely to inflame momentarily but would be unlikely to continue to burn. The danger of serious fires would come from heat radiation entering buildings through windows and igniting furnishings and other materials likely to be found indoors.

As the heat radiations would travel in straight lines the lower floors of buildings in a city would be protected to some extent by surrounding buildings from heat radiation given off by a bomb exploded over the city. Precautions would have to be taken in all rooms having a view of the sky.

The bulletin shows that it would be desirable to remove all paper, textiles, upholstery and other easily combustible substances from the danger area near the windows and the parts of the floors where radiations from the sky might fall. Steps should also be taken to prevent radiation entering the room, and some possible simple ways of doing this are described. This could be done by white-washing or painting the windows or masking off any part of the windows that gives a view of the sky. Treated covers would also help to protect pieces of furniture or other objects which could not be removed from the danger areas of the rooms. Leather or woollen gloves and woollen or treated cotton balaclavas will help to protect the hands and head.

A section of the bulletin deals with methods of locating ground zero, the point immediately below the atomic explosion. The rapid location of this point would be important for rescue purposes.

After a bomb has fallen it is important for rescue purposes to locate ground zero, the point immediately below the exploding bomb, as soon as possible. The bulletin describes several instruments which could be used for this purpose, including an instrument something like a sundial, having a table graduated in degrees and a central pin which casts a shadow when heat rays from a bomb fall on it. If the table of this instrument is treated beforehand with paint which turns red when heated, the shadow will stand out in its original colour against the red background. Readings from two or more of these instruments at a distance from each other will give the location of ground zero and elevation of the bomb at the time of the explosion. More complicated detectors are also described.

Soil Stabilisation speeds Road Construction

'Soil stabilisation' is the term applied to the method of road construction in which soils are stabilised, usually by mixing them with cement or bituminous materials, so that their load-bearing capacity is increased and their susceptibility to variations in water content and to weathering is lessened. This technique, which can be used to build roads and aerodrome runways rapidly, has undergone considerable development in the past thirty years. It is economical of transport and labour as well as time.

Though the method has found only limited use in Britain, it is important for the Commonwealth. Here American experience with soil stabilisation is applicable and with this end in view the Road Research Laboratory sent one of its staff, K. E. Clarke, to the U.S.A. in 1951. His report has now been published by H.M. Stationery Office (1954, price 2*s*. 6*d*.) under the title *The Use of Stabilised Soil for Road Construction in the U.S.A.* (Road Research Technical Paper No. 29). This publication deals first with techniques for soil survey, the classification of soils and the design of pavements. Methods of stabilisation using cement, bituminous materials and chemicals are then described in detail and the performance of main, secondary and urban roads constructed in this way is considered. A section on mechanical plant for stabilised soil road construction deals with mix-in-place equipment, travelling-plant-mix equipment and miscellaneous plant.

Refrigeration and Brain Surgery

The refrigeration technique devised by French surgeons and described elsewhere in this issue is being tried out in other countries.

From the U.S.A. there has since come a report about a ten-week-old boy was successfully 'frozen' by refrigeration anaesthesia to a body temperature of 66·2 degrees for a delicate brain operation at a hospital in Alexandria, Virginia.

Surgeons who performed the operation believe that the temperature was the lowest ever induced in medical history. (Previously an eight-year-old boy's body temperature was reduced to 80 degrees for a heart operation at a children's hospital last March.)

The patient in the Alexandria hospital operation had suffered severe convulsions, and tests showed these were caused by a blood clot on the brain.

The two brain surgeons who examined him agreed he must have an operation, designed to remove the clot and to clip the blood vessels responsible for the condition. They decided to use the refrigeration-anaesthesia process because it slows the flow of blood. There was a risk that the boy might bleed to death during the operation unless his circulation could be retarded. A specialist was brought from George Washington University Hospital to perform the freezing technique.

The boy's body temperature was lowered by surrounding him with nylon bags filled with ice. When his temperature reached 66·2, his pulse was down from a normal 140 to 70. His breathing was controlled artificially and an electrocardiograph recorded the heart action.

After the two-and-a-half-hour operation was over, the boy's temperature was gradually restored to normal with hot-water bottles. He began breathing under his own power when his temperature rose up to 71 degrees.

Botanists' Centenaries

This year brings the centenaries of four botanists, three of them British and one Anglo-Danish, and all of them explorers or

travellers who searched far and wide for plants or specimens.

PHILIP BARKER WEBB (1793–1854) went to Oxford and Lincoln's Inn before he inherited a fortune and became free to devote his whole time to botanical exploration. With the Chevalier Parolini, Webb went on a tour of the Middle East to collect specimens; while in 1825 he followed this tour with a year's wanderings in Spain, collecting birds, fish and shells as well as plants, before visiting Portugal. The next two years found him in the Canaries with Savin Bertholet, a French botanist, an association which caused Webb to assemble in Paris the finest herbarium in the world. The two companion botanists then proceeded to put fourteen years' work into their *Histoire Naturelle des Iles Canaries*, Webb dealing with most of the botany and geology.

NATHANIEL WALLICH (1786–1854) came to do important work for our country because of an event in history outside the realms of science. Born in Copenhagen, be became surgeon to the Danish settlement at Serampore, and in 1813 he decided to enter the English service when that settlement was captured by our forces. Two years later his abilities were recognised with his appointment as superintendent of the Calcutta botanical gardens, a move which determined his life's work. For Wallich went on to explore Nepal, Lower Burma and other areas in the Far East; then returned to England to publish in 1830–32 his *Plantae Asiaticae Rariores*. Wallich was honoured by the country of his adoption, becoming a vice-president of the Linnean Society and being elected F.R.S. in 1829.

HENRY MARSHALL WARD, born 100 years ago at Hereford, was a pupil of T. H. Huxley at the Normal School of Science, South Kensington; then he became a student at Owens College, Manchester, and finally, rounded off his extensive studies by going to Cambridge, where he took first-class honours. It was at Wurzburg that he carried out his first piece of research work on the development of the embryo sac, a study which he continued at Kew. As with Wallich, it was a Far Eastern post which inspired Ward; this occurred when the Colonial Office sent him to investigate the Ceylon coffee-leaf disease. There he studied tropical fungi before returning to England to take up a research fellowship at Manchester, after which he took up the chair of botany at Cooper's Hill. For ten years Ward occupied this chair at the Royal Indian Engineering College, during which period a great harvest of publications derived from his pen. He wrote on 'Timber and its Diseases', 'An Introduction to Forest Botany', 'Lectures on the Physiology of Plants', and other topics, all of which literary work was additional to his important research work on root nodules, on sources of nitrogen and on symbiosis. Ward also showed his versatility in subjects of research when he identified eighty species of bacteria in Thames water. He was honoured by the Linnean Society and made a Fellow of the Royal Society. On the death of Prof. Charles Babington of Cambridge, Ward was elected to the chair of botany at that university.

The discoverer of uranium fission, Dr. Otto Hahn (left) photographed with Dr. James B. Conant, U.S. High Commissioner to Germany, in front of the atomic energy exhibit at the recent West Berlin industries exhibition. In 1945 Dr. Hahn received the Nobel Prize for Chemistry which had been awarded him the previous year while Hitler's decree that prevented German nationals from accepting Nobel Prizes was still in force. Since 1946 he has been president of the Max-Planck Gesellschaft (formerly the Kaiser-Wilhelm Gesellschaft), which is responsible for a number of important research institutes.

East Malling's Annual Report for 1953

The East Malling Research Station's annual report for 1953 has just been published, price · 12*s.* 6*d.* (including postage inside Britain).

The report includes the text of the sixth Amos Memorial Lecture by Professor R. H. Stoughton, on the growth and development of fruit plants, and the results of a very detailed soil survey of the research station (recently completed by B. S. Furneaux), which is illustrated by coloured maps of the solid geology and of the distribution of the soils over the whole station. The effects of management on soil variation form the subject of an accompanying paper.

A wide range of subjects is covered by the 24 papers in the report; these cover such matters as new apple rootstocks, the M.IX crosses, which give an even wider influence on size of tree than the Malling rootstocks; raspberry breeding; forecasting the time of blossoming of apples; rootstock-scion interaction; leaf-bud cuttings; rubbery wood virus; the spread of strawberry virus diseases; *Verticillium* wilt of hops; orchard insect records for 1953; gall midges; and ovicides for the control of the Fruit Tree Red Spider mite.

THE BOOKSHELF

Minerals for the Chemical and Allied Industries

By Sydney J. Johnstone (*London, Chapman & Hall, 1954, 692 pp., 75s.*)

During the war years it was customary in all branches of industry, but especially in the chemical and allied industries, to 'make do' with the materials then available. This frequently involved the use of substitute minerals, a process which has continued in the post-war years to such an extent that minerals and mineral products are still being put to more and more uses in many industries; thus one finds that in many cases the useless gangue minerals and waste dumps produced by the metalliferous miner of a century ago have now become more important than the minerals for which he once searched. Many old mine dumps have, in recent years, been reworked for minerals once considered commercially useless. This trend of putting minerals to new uses is not merely a reflexion of inherited wartime shortages or of wartime habits, it indicates the fuller use to which the world's mineral resources are being put. Not only are minerals long known to man being more widely employed, but each year sees an increase in the number of minerals used by all branches and sections of industry.

The arrangement within this book of the immense amount of factual material concerning minerals is straightforward. Each mineral is dealt with in sections alphabetically under such headings as world production; uses; methods of extraction; British and American Standard Specifications. In some ways this book closely resembles some textbooks (mainly American) on Economic Geology and Mineral Deposits; the essential difference being that in this book the treatment is mainly from the producer's and consumer's viewpoints. It is comprehensive, very detailed and right up to date.

In recent years it has become necessary for both mineral producers and consumers to work to rigid specifications for the various grades of their mineral products and raw materials. The search for such specifications often means much searching of technical literature in many specialised publications. In this book, which was written by an author who has had a lifetime of experience in the marketing and utilisation of minerals, comprehensive lists of both British and American Standard Specifications accompany each section on a particular mineral or group of minerals. In these lists and the full bibliographies in each section lies the great value of this monumental collection of data upon economic minerals. Obviously this book will be of considerable value to those engaged in the mineral and chemical industries as well as those who are students of economic geology and geography in the universities and technical colleges. It will become a popular reference book. F. A. HENSON

A Textbook of Radar

By the Staff of the Radiophysics Laboratory, C.S.I.R.O., Australia. (*London Cambridge University Press, 2nd edition 1954, 617 pp. 45s.*)

This textbook of radar is the second edition of a volume which was first published in Australia in 1947. It covers the basic principles and all the important aspects of radar and its applications. Although the book is the collective work of twenty authors, a high degree of coordination has been achieved and there is very little overlapping amongst the various sections.

The book is said to be "suitable for graduate and research students and engineers engaged in research and development in industry". This is certainly true, and as a general work covering the whole field of radar it will serve as an excellent textbook, provided always that the reader has a good grounding in basic radio engineering. The mathematical knowledge required of the reader is that covered in a university, or possibly Higher National Certificate, course in communication engineering. The first two chapters provide an introduction and a statement of the fundamental problems; the various sections of the subject are then discussed in the succeeding thirteen chapters. As far as transmission is concerned, there are chapters on magnetrons, modulators, microwave transmission, cavity resonators, aerials and aerial duplexing; on the receiving side there is a chapter on the general aspects of receivers, and this is followed by chapters on local oscillators, frequency convertors, amplifiers and display and ranging circuits. Three further chapters discuss military and civil radar systems. The last chapter deals with the application of radar to marine and air navigation, astronomy and meteorology.

Quite a number of references to the vast literature of the subject have been added to this edition. As a textbook, however, its usefulness would be increased if still more references were given, as the treatment is not always detailed, and is sometimes qualitative.

The rationalised MKS system of units is used throughout. The text is supported by a large number of excellent diagrams and illustrations, and the treatment is clear and well written. WM. FRASER

Changing Greenland

By Geoffrey Williamson (*London, Sidgwick & Jackson, 1953, 280 pp., 18s.*)

The wild wind-swept wastes of the polar regions have always attracted English explorers; the magnitude of their contribution to polar research is reflected by the number of their names which stud the maps of these inhospitable areas. This call of the lands of ice and snow has clearly been heard by the author of this book, who writes comprehensively about Greenland and his own recent experiences in that country. At first the author almost conveys the impression that he is simply extolling the tourist attractions of this increasingly important island, but he does achieve a rather bigger total effect, and this attractive and well-illustrated book is well worth reading by all who are interested in the world in which they live. The foreword by Denmark's Minister of Foreign Affairs indicates Danish approval of this volume, and it brings out the unity of purpose which the Danes and the English have always held in polar exploration. Finally, either before or after reading this book, one would be well advised to read the autobiography of Peter Frenchen, a intrepid Dane, who, along with Knud Tasmussen, first established Thule and got to know the Greenland eskimos before they were affected by contact with American civilisation.

Our Moon

By H. Percy Wilkins (*London, Frederick Muller, 1954, 180 pp., 12s. 6d.*)

As Dr. J. G. Porter remarks in his foreword to this book, modern probing into the far interstellar spaces does not mean that the moon, our next-door neighbour, is not still full of interest and unresolved problems. Mr. Wilkins, who is director of the Lunar Section of the British Astronomical Association, describes here in great detail, illustrated by photographs and by original drawings of his own and of Mr. Patrick Moore, the lunar scenery as studied through the 33-in. refractor at Meudon Observatory. Certainly anyone who reads these pages, for preference following this with the use of even the smallest telescope, will learn a great deal about the moon.

A cold, dead world, airless and waterless, might be expected never to show any changes upon its surface. The impact of meteors, it is true, could conceivably leave some trace visible from the earth, especially when there is no appreciable atmosphere to serve as a shield. But whereas nothing of this kind has been detected, strange alterations in the appearance of certain features have frequently been reported. The variation of light and shadow according to the direction of the sun's rays at any given moment may, of course, account for much, but apparently not for all; and Mr. Wilkins himself has observed many 'mysterious happenings', as he terms them. Occasionally the floors and sides of craters seem to be covered with mist or even, perhaps, with some sort of temporary vegetation, doubtless of a very lowly order. Thin gases and moisture, possibly mixed with dust, may escape at times from the moon's interior, and affect the surface colouring. There are great enough differences in temperature between day and night on the moon to suggest that physical conditions there are not entiraly static.

Mr. Wilkins refers to an old theory (which was held by the younger Herschel, among others, in the last century) that

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water and air might have accumulated on the other side of the moon, the earthward side being in effect the face of an enormous mountain some forty miles high. The theory may be easily demolished, but the fact that it was ever seriously put forward indicates how oddly reluctant the human mind is to accept the moon as a mere desert. Modern inquirers, however, are more fortunate than their predecessors; they may reasonably hope that one day the secrets of the moon will be laid bare, in the only manner that can make this possible—by the personal visit of explorers from the earth. E. N. PARKER

3-D Kinematography and New Screen Techniques.

By Adrian Cornwell-Clyne (*London, Hutchinson's Scientific and Technical Publications, 1954, 527 pp., 18s.*)

Introduction to 3-D

By H. Dewhurst (*London, Chapman & Hall, 1954, 152 pp., 21s.*)

The first of these two books sets out to describe in layman's language the various new film processes of 3-D, curved and wide-screen, and stereophonic sound.

Stereoscopic films are not the easiest of subjects to write lucidly about, and all honour to Major Cornwell-Clyne for his courage in tackling the job. The author is well known for his standard treatise, *Colour Cinematography* (reviewed in DISCOVERY, July 1952); the present book suffers, although to a far less extent, from the same defects—a rather muddled style of writing, leading to some lack of clarity and much repetition and the inclusion of irrelevant detail. The quality of his new book is uneven: the book is much clearer on some aspects of the subject than on others.

Chapter 1, on the eye and depth perception, is on the whole excellent; so is the outline of the general theory of the taking and projection of 3-D films (here the author is largely indebted to the writings of the Spottiswoodes). The author is also commendably brief and realistic in his chapter on the costly, top-heavy Cinerama process, which he dismisses as a "super-spectacle in a class by itself".

By contrast, the chapter on the different methods of projecting 3-D films is at times far from clear, and contains—presumably for completeness' sake—detailed descriptions of fantastically impracticable systems of projection. The same chapter also gives details of the manufacture of polaroid sheet, which is interesting but hardly keeping to the point. The section on auto-stereoscopy (that is, grid or raster stereoscopy, in which no spectacles need be worn) is very complete, but again suffers from lack of clarity; at times the author talks about still, not motion-picture, cameras without specifically saying so.

The chapter on wide-screen presentation is again cluttered up with much dead wood in the form of unnecessary calculations, tables of figures, etc.; the whole subject could surely have been put across far more succinctly. The chapters on stereophonic sound and on sub-standard 3-D and wide-screen methods are straightforward enough, while that on drawing a 3-D cartoon seems hardly necessary since most of it repeats statements made elsewhere in the book. There is a glossary which is of doubtful value, and Armin J. Hill's authoritative paper written on behalf of the Motion Picture Research Council has been included as an Appendix; most of this, however, is far above the head of the layman for whom the book is intended. The author makes several dogmatic pronouncements on matters of aesthetics, such as pictorial composition, the ultimate goal of the film, etc., with which film technicians will find plenty to quarrel; he also dwells too much on the film as 'drama', and tends to ignore the documentary and instructional possibilities of 3-D.

With all its faults, however, there are many good things in the book, and the newcomer to the subject can learn plenty from it if he is prepared to do a bit of sifting. Perhaps the author's most inspiring thought occurs in his last paragraph: "We may hope to see many remarkable films . . . in which light and colour could be used to reveal forms in motion in an unfamiliar space."

* * *

Hard on the heels of Major Cornwell-Clyne's book appeared another on the same subject, this time by H. Dewhurst of the Ministry of Supply's Radar Research Establishment at Malvern, and comparisons are inevitable. The second volume is more concise than the other, and Dewhurst's style is perhaps easier reading on the whole. He rather sensibly devotes much less space than Cornwell-Clyne to the innumerable variations on the wide-screen theme, and his trump card is his last chapter, on stereoscopic television possibilities. On the whole, for the student or layman who wants a quick introduction to, and an overall picture of the subject, and does not want to get too deeply involved in detail, one would recommend this book, because of its greater compactness of thought.

Mr. Dewhurst's book starts off well with a brief but clear description of the human eye and vision, leading up to binocular factors in stereoscopic seeing. The next two chapters, however, on The Geometrical Requirements of Stereoscopic Re-presentation, and Projection Requirements and Methods are disappointingly unclear, and seem to contain vague inconsistencies. This is a great pity, as they let down the rest of the book.

Here this reviewer would like to steal a little space to air a private 'bind' about writers on 3-D in general: it concerns the lack of a standard system of nomenclature and symbols. At least four groups of investigators in this field have produced books or papers recently—Armin J. Hill; the Spottiswoode brothers in this country; Dewhurst; and Maurice Bonnet in France. To anyone trying to follow all four theories, and to correlate points of agreement or divergence, the complete lack of similarity in the nomenclature used in the none-too-simple mathematics, has made the task well-nigh impossible.

The next chapter, on Viewing Aids, is by contrast excellently written and very clear: it contains, in fact, the plainest exposition of 'integral' and 'two picture' raster and lenticular viewing systems that this reviewer has ever read, and makes clear the essential difference between truly integral systems of the 'Roving Eye' type used in stills, and 'two-picture' or 'Fixed Eye' systems of the Russian movie type. While Dewhurst points out that the first type of system has so far yielded only still photographs of the 'Deep Pictures' type, he does not perhaps go far enough in explaining *why* this is so—not, at any rate, until the final chapter on television: that in fact the limiting factor is the resolving power or grain of the photographic emulsion of the film. Only with vastly finer-grained emulsions may the tiny ciné frame be able, in the distant future, to carry the much greater amount of 'information' necessary for the 'Roving Eye' type of presentation, where the audience will be able to sit almost anywhere in the theatre and waggle their heads about as much as they like—without, of course, needing to wear spectacles.

The rest of the book is reasonably clear and well written. The author not unnaturally devotes quite a bit of space to descriptions of various beam-splitting and 'beam-spreading' optical systems for use with standard or sub-standard movie cameras, since he is himself the inventor of successful systems of this type on 16 mm. He also stresses throughout the book his belief that for 'natural' stereoscopic reproduction of a scene the camera lenses must always be kept separated by the same distance as that between the human eyes: a point over which he is at variance with the Spottiswoodes' theory.

The final chapter, on Stereo Television, sets out some of the possibilities in this direction, including special spectacles invented by the author, but holds out little hope of immediate developments in this field.

This book is well illustrated, and includes some excellent line diagrams and airbrush drawings by Miss V. M. Francis.

DENIS SEGALLER

Macro and Semimicro Qualitative Inorganic Analysis

By A. I. Vogel (*London, Longmans, Green, 4th edn., 1954, 663 pp., 22s.*)

Dr. Vogel has given a new title to the fourth edition of his textbook of inorganic analysis. This indicates the increasing importance of semimicro methods over the eight years since the last edition appeared. Much new material has been added so that this volume is a complete revision besides incorporating a new section on inorganic paper chromatography. It is recommended for use by students of chemistry up to Honours degree standard, and is exceptionally good value for the price at which it is published.

Classified Advertisements

OFFICIAL APPOINTMENTS

ASSISTANTS (SCIENTIFIC): The Civil Service Commissioners invite applications for pensionable posts. Applications may be accepted up to 31 December, 1954, but early application is advised as an earlier closing date may be announced either for the competition as a whole or in one or more subjects. The Interview Board will sit at frequent intervals.

Age at least 17½ and under 26 years of age on 1 January, 1954, with extension for regular service in H.M. Forces, but candidates over 26 with specialised experience may be admitted.

Candidates must produce evidence of having reached a prescribed standard of education, particularly in a science or mathematical subject. At least two years' experience in the duties of the class gained by service in a Government Department or other civilian scientific establishment or in technical branches of the Forces essential in one of the following groups of scientific subjects:

(i) Engineering and physical sciences.
(ii) Chemistry, bio-chemistry and metallurgy.
(iii) Biological sciences.
(iv) General (including geology, meteorology, general work ranging over two or more groups (i) to (iii) and highly skilled work in laboratory crafts such as glass-blowing).

Salary £250 (at 18) to £520 (men) or £435 (women). Starting pay up to £380 (men) or £340 (women) at 25. Somewhat less in provinces. Opportunities for promotion.

Further particulars and application forms from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S.59/54.

EXPERIMENTAL OFFICERS AND ASSISTANT EXPERIMENTAL OFFICERS in various Government Departments. The Civil Service Commissioners invite applications for pensionable posts. Applications may be accepted up to 31 December, 1954, but forms should be returned as soon as possible as an earlier closing date may be announced either for the competition as a whole or in one or more subjects. Interview Boards will sit at frequent intervals.

The posts are divided between following main groups and subjects: (*a*) Mathematical and Physical Sciences, (*b*) Chemistry and Metallurgy, (*c*) Biological Sciences, (*d*) Engineering subjects and (*e*) Miscellaneous (including e.g. Geology, Library and Technical Information Services).

Age limits: For Experimental Officers, at least 26 and under 31 on 31 December, 1954; for Assistant Experimental Officers at least 18 and under 28 on 31 December, 1954. Extension for regular service in H.M. Forces.

Candidates must have at least one of a number of specified qualifications. Examples are Higher School Certificate, General Certificate of Education, Scottish Leaving Certificate, Scottish Universities Preliminary Examination, Northern Ireland Senior Certificate (all in appropriate subjects and at appropriate levels), Higher National Certificate, University degree. Candidates taking their examinations in 1954 may be admitted. Candidates without such qualifications may be admitted exceptionally on evidence of suitable experience. In general a higher standard of qualification will be looked for in the older candidates than in the younger ones.

Salary (London):

Experimental Officer
£720–£890 (men); £625–£760 (women).

Assistant Experimental Officer
£290 (at age 18) to £645 (men), £545 (women). Starting pay up to £520 (men) or £490 (women) at 26. Somewhat lower outside London. Promotion prospects.

Further particulars and application forms from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S.94-95/54.

COMMONWEALTH OF AUSTRALIA

APPOINTMENT NO. 462/51 OF PHYSICIST, BIOPHYSICIST OR PHYSICAL CHEMIST

THE COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION invites applications for appointment to a position of Senior Research Officer or Research Officer at its Biochemistry Unit, Wool Textile Research Laboratories, Parkville, Melbourne, Victoria.

Duties: To participate in an intensive research programme concerned with the structure of fibrous proteins, polypeptides and related compounds by X-ray, infrared and optical techniques.

Qualifications: University honours degree in science with physics or chemistry as major subject or equivalent qualifications. Some research experience in this field would be an advantage but is not essential.

Salary: Within the range of Senior Research Officer, £A1322 to £A1472 p.a. (actual), or Research Officer, £A854 to £A1262 p.a. (actual).

Salary includes a cost-of-living adjustment of £A198 p.a. Fare to Australia (including those of wife and family) will be paid. Appointee may be granted superannuation privileges.

Applications, referring to Appointment No. 462/51, and stating full name, place and date of birth, nationality, marital state, present employment, particulars of qualifications and experience, and of war service, if any, accompanied by names and addresses of at least two persons willing to act as referees, if so required, and copies of not more than four testimonials, should reach the undersigned by 20th November, 1954.

W. IVES
Chief Scientific Liaison Officer

Australian Scientific Liaison Office,
Africa House,
Kingsway,
London, W.C.2

UNIVERSITY OF WESTERN AUSTRALIA

APPLICATIONS are invited for the position of LECTURER IN GEOLOGY. The appointee will work under the direction of the Professor of Geology and will be required to conduct lecture, laboratory and field classes in Palaeontology and Stratigraphy, and participate in stratigraphical field work. Preference will be given to an applicant with palaeontological research and field experience.

The salary range, which is under review at present, is £A859 × £A50–£A1259 per annum which includes a present cost-of-living allowance of £A259. According to qualifications and experience an appointment may be made within the range. The position is superannuated along the lines of the British F.S.S.U.

An allowance is made towards travelling expenses.

The successful applicant will be expected to commence duties as early as possible in 1955.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1.

The closing date for the receipt of applications, in Australia and London, is *19th November, 1954.*

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S.W.7. or phone KNIghtsbridge 2534
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Continued on next page

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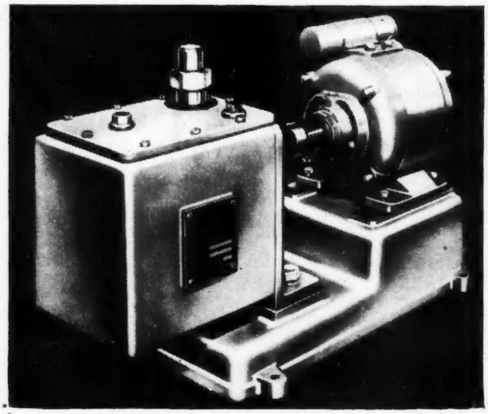

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The Amazing Potentialities of Memory

I LITTLE thought when I arrived at my friend Borg's house that I was about to see something truly extraordinary, and to increase my mental powers tenfold.

He had asked me to come to Stockholm to lecture to the Swedes about Lister and other British scientists. On the evening of my arrival, after the champagne, our conversation turned naturally to the problems of public speaking and to the great labour imposed on us lecturers by the need to be word perfect in our lectures.

Borg then told me that his power of memory would probably amaze me—and I had known him, while we were studying law together in Paris, to have the most deplorable memory!

So he went to the end of the dining room and asked me to write down a hundred three-figure numbers, calling each one out in a clear voice. When I had filled the edge of an old newspaper with figures, *Borg repeated them to me in the order in which I had written them down and then in reverse order, that is beginning with the last number. He also allowed me to ask him the relative position of different numbers: for example, which was the 24th, the 72nd, and the 38th, and I noticed that he replied to all my questions at once and without effort, as if the figures which I had written on the paper had been also written in his brain.*

I was dumbfounded by such a feat and sought in vain for the trick which enabled him to achieve it. My friend then said: "The thing you have just seen and which seems so remarkable is, in fact, quite simple; everybody has a memory good enough to do the same, but few indeed can use this wonderful faculty."

He then revealed to me how I could achieve a similar feat of memory, and I at once mastered the secret—without mistakes and without effort—as you too will master it tomorrow.

But I did not stop at these amusing experiments. I applied the principles I had learned in my daily work. I could now remember, with unbelievable facility, the lectures I heard and those which I gave myself, the names of people I met—even if it was only once—as well as their addresses, and a thousand other details which were most useful to me. *Finally, I discovered after a while that not only has my memory improved, but that I had also acquired greater powers of concentration; a surer judgment—which is by no means surprising since the keenness of our intellect is primarily dependent on the number and variety of the things we remember.*

If you would like to share this experience and to possess those mental powers which are still our best chance of success in life, ask E. A. Borg to send you his interesting booklet *The Eternal Laws of Success*—he will send it free to anyone who wants to improve his memory. Here is the address: *E. A. Borg, c/o Aubanel Publishers, 14 Lower Baggot Street, Dublin.*

Write now—while copies of this booklet are still available. L. CONWAY

A Way Found Out

'I HAVE OFTEN THOUGHT', said the inventive English genius, Dr. Robert Hooke, 'that probably there might be a way found out, to make an artificial glutinous composition, much resembling, if not full as good, nay better, than that Excrement, or whatever other substance it be out of which, the Silk-worm wire-draws his clew'. That was in 1665, but two hundred years were to pass before the scientists' search for ways and means of producing textile fibres artificially began in earnest. Today, we may be thankful that their quest has been successful, for the demand for textiles now tends to outstrip nature's own resources of the cotton plantation, the silkworm and the sheep. Noteworthy among the new man-made fibres of today is one perfected in the laboratories of I.C.I.'s Nobel Division. Known as 'Ardil', this new fibre is soft and warm—and unattractive to moths. Fabrics containing it are endowed with a silky, smooth handle, and a friendly 'feel'. Equally important is the fact that 'Ardil' is available in exactly the deniers and staple lengths that the textile manufacturer needs, wh its price is low and stable.

A new I.C.I. factory, built at Dumfries at a cost £3,000,000, is capable of manufacturing 'Ardil' staple the rate of 20,000,000 lbs. a year. The staple goes to t spinners to be blended with other fibres and to be sp into yarn; the yarn then goes to weavers, who transfor it into fine, soft fabrics, which can be made up into coa and suits, and warm, light-weight winter dresses, or such is the versatility of 'Ardil'—into carpets, blanke and rugs.

'Ardil' is made, by a complex chemical process, fro the protein of the groundnut, which grows abundant in many parts of the Commonwealth. It is, therefor not only an outstanding new material for the texti trade but an example of how I.C.I. research and develop ment are helping to put the natural resources of t Commonwealth to fuller use.

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